Malathion Criteria Derivation
DRAFT

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1. Introduction

An updated methodology for deriving freshwater water quality criteria for the protection of aquatic life was developed (TenBrook *et al.* 2009a). The need for a new methodology was identified by the California Central Valley Regional Water Quality Control Board (CVRWQCB 2006) and findings from a review of existing methodologies (TenBrook & Tjeerdema 2006, TenBrook *et al.* 2009b). This new methodology is currently being used to derive criteria for several pesticides of particular concern in the Sacramento River watershed. The methodology report contains an introduction (Chapter 1); the rationale of the selection of specific methods (Chapter 2); detailed procedure for criteria derivation (Chapter 3); and a chlorpyrifos criteria report (Chapter 4). This criteria report for malathion describes, section by section, the procedures used. Also included are references to specific sections of the methodology procedure detailed in Chapter 3 of the report so that the reader can refer to the report for further details (TenBrook *et al.* 2009a).

2. Basic information

Chemical: Malathion (Fig. 1)
IUPAC: diethyl 2-dimethoxyphosphinothioylsulfanylbutanedioate
Alternate names: diethyl (dimethoxyphosphinothioylthio) succinate,
S-1,2-bis(ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate
Chemical Formula: $C_{10}H_{19}O_6PS_2$

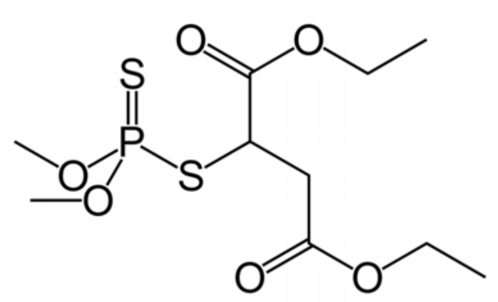


Figure 1. Structure of malathion (public domain: http://en.wikipedia.org/wiki/File:Malathion.png)

Synonyms: carbofos, carbophos, maldison, mercaptothion (ExToxNet)
Trade names: celthion, cythion, dielathion, El 4049, emmaton, exathios, fyfanon and hilthion, karbofos, maltox (ExToxNet)

CAS Number: 121-75-5

USEPA PC Code: 057701 (Kegley *et al.* 2008)
CA DPR Chem Code: 367 (Kegley *et al.* 2008)

3. Physical-chemical data

Molecular Weight
330.358 g/mol (Howard 1989; Mackay 2006)

Water Solubility
130 mg/L (25 ^{o}C) (Kidd *et al.* 1991)
143 mg/L (20 ^{o}C) (Howard 1989)
145 mg/L (20-23^{o}C) (Cheminova 1988)
145, 164 mg/L (20^{o}C, 30^{o}C) (Kamrin and Montgomery 2000)
148.2 mg/L (25^{o}C) ^{14}C-malathion (Kabler 1989)
150 mg/L (25 ^{o}C) (Hartley and Graham-Bryce 1980)
Geometric mean: 146.16 mg/L

Melting Point
1.4 (Lide 2004)
2.85^{o}C (Kidd *et al.* 1991)
2.9 ^{o}C (Budavari *et al.* 1996; Howard 1989)
3^{o}C (Barton 1988)
Geometric mean: 2.43^{o}C

Boiling Point
120^{o}C (0.2 mmHg) (Melnikov 1971)
156-157^{o}C (0.7 mmHg) (Barton 1988; Howard 1989)

Density
1.23 g/mL (20^{o}C) (Barton 1988)
1.23 g/mL (25^{o}C) (Mackay 2006)
1.2 g/mL (25^{o}C) (Verschueren 1996)
Geometric mean: 1.22 g/mL

Vapor Pressure
1.05×10^{-3} Pa (20^{o}C) (Howard 1989)
1.30×10^{-3} Pa (20^{o}C) (Hartley and Graham-Bryce 1980)
5.33×10^{-3} Pa (20^{o}C) (Verschueren 1996)
5.30×10^{-3} Pa (30^{o}C) (Kidd *et al.* 1991; Tondreau 1987)
1.67×10^{-4} Pa (20^{o}C) (Melnikov 1971)
4.57×10^{-4} Pa (25^{o}C) (Barton 1988)
Geometric mean: 1.20×10^{-3} Pa

Henry's Law Constant (K_H)
2.03×10^{-3} Pa m^3/mol (25 ^{o}C, calculated) (Howard 1989)
2.30×10^{-3} Pa m^3/mol (20^{o}C, calculated) (Mackay 2006)

3.22×10^{-3} Pa m^3/mol (25 ^oC, calculated)
4.90×10^{-4} Pa m^3/mol (23 ^oC) (Kamrin and Montgomery 2000)
Geometric mean: 1.65×10^{-3} Pa m^3/mol

Log K_{OW}
2.36-2.89 (Kamrin and Montgomery 2000)
2.36 (Howard 1989)
2.75 (Barton 1988)
2.75 (Tomlin *et al.* 1994)
2.89 (Verschueren 1996)
3.38-3.57 (HPLC correlations) (Mackay 2006)
Geometric mean: 2.84

Organic Carbon Sorption Partition Coefficients (log K_{OC})
2.36-2.45 (Mackay 2006)
2.61 (Kamrin and Montgomery 2000)
3.25 (Karickhoff 1981)
2.83, 3.29, 2.50 (estimated K_{OW})
3.07 (Sabljic *et al.* 1995)
Geometric mean: 2.77

Bioconcentration Factor

Table 1. Bioconcentration factors (BCF) for malathion.

Species	**Common name**	**log BCF**	**Tissue, exposure duration**	**Reference**
Cyprinus carpio	Common carp	0.65	Muscle, 7 d	(Tsuda *et al.* 1990)
Cyprinus carpio	Common carp	0.75	Flesh, 4 d	(Bender 1969b)
Cyprinus carpio	Common carp	1.11		(Mackay 2006)
Cyprinus carpio	Common carp	0.85		(Debruijn and Hermens 1991)
Gnathopogon coerulescens	Willow shiner	1.53	Whole fish, 7 d	(Tsuda *et al.* 1989)
Lepomis macrochirus	Bluegill	1.25	Fillet, 28 d	(Forbis 1994)
Lepomis macrochirus	Bluegill	2.01	Whole fish, 28 d	(Forbis 1994)
Oncorhynchus kisutch	Coho salmon	1.47		(Howard 1991)
Paneaus setiferus	White shrimp	2.94		(Howard 1991)
Paneaus aztecus	Brown shrimp	2.98		(Howard 1991)
Pseudorasbora parva	Topmouth gudgeon	2.00		(Debruijn and Hermens 1991)
Salvelinus namaycush	Lake trout	0.87		(Howard 1991)
Triaenodes tardus	Caddisfly	0.40		(Howard 1991)

Environmental Fate

Table 2. Malathion hydrolysis and photolysis and other degradation. (NR: not reported).

	Half- life (d)	**Water**	**Temp (°C)**	**pH**	**Reference**
Hydrolysis	40	Buffer	0	8	Wolfe *et al.* 1977
	36 hr	Buffer	27	8	Wolfe *et al.* 1977
	1 hr	Buffer	40	8	Wolfe *et al.* 1977
	10.5	Phosphate buffer	20	7.4	Freed *et al.* 1979
	1.3	Phosphate buffer	37.5	7.4	Freed *et al.* 1979
	107	Phthalate buffer	25	5	Teeter 1988
	6.21	Phosphate buffer	25	7	Teeter 1988
	0.49	Borate buffer	25	9	Teeter 1988
Aqueous Photolysis	156	Acetate buffer	25	4	Carpenter 1990
	94	Acetate buffer	25	4	Carpenter 1990
Degradation	4.4-4.7	Estuarine	20	NR	Druzina & Stegu 2007
	77.9	Surface	4	8	Druzina & Stegu 2007
	19.8	Surface	25	8	Druzina & Stegu 2007
	51.3	Groundwater	25	6	Druzina & Stegu 2007
	13.1	Groundwater	25	7	Druzina & Stegu 2007
	7.1	Groundwater	25	8.5	Druzina & Stegu 2007
	68.6	Groundwater	4	7	Druzina & Stegu 2007

4. Human and wildlife dietary values

Food tolerances and FDA action levels are not established for malathion (USEPA 2000a; 2002; USFDA 2000).

Wildlife LC_{50} values (dietary) for animals with significant food sources in water

Mallard duck	1485 mg/kg	(Hudson *et al.* 1984)

Wildlife dietary NOEC values for animals with significant food sources in water

Mallard duck	1200 mg/kg	(Pedersen and Fletcher 1993)

No other dietary values were found for malathion for wildlife species with significant food sources in water.

5. Ecotoxicity data

Approximately 200 original studies on the effects of malathion on aquatic life were identified. Single-species effects studies that were rated as relevant (R) or less relevant (L) were summarized in data summary sheets (see section 3-2.2, TenBrook *et al.* 2009a). Information in these summaries was used to evaluate each study for reliability using the rating systems described in the methodology (section 3-2.2, TenBrook *et al.* 2009a). Copies of completed data summaries for all studies rated relevant and reliable (RR) for criteria derivation are included in the Appendix of this report. Malathion studies deemed irrelevant by an initial screening were not summarized (e.g., studies involving rodents or *in vitro* exposures). Ecosystem level studies were summarized in section 14. All data rated as acceptable or supplemental for criteria derivation are summarized in Tables 3-10 found at the end of this report.

Using the data evaluation criteria (section 3-2.2, TenBrook *et al.* 2009a), 36 acute studies yielding 105 toxicity values were judged reliable and relevant for criteria derivation (Tables 3 and 4). There were nine chronic studies yielding six toxicity values that were judged reliable and relevant for criteria derivation (Table 5 and 7). Seventy studies were rated RL, LL, or LR and may be used as supplemental information for evaluation of derived criteria (Table 8).

Twelve mesocosm, microcosm and ecosystem (field and laboratory) studies were found. Two of these studies were rated R or L and may be used as supporting data. One relevant study on the effects of malathion on wildlife was found.

6. Data reduction

Multiple toxicity values for malathion for the same species were reduced into one species mean acute value (SMAV) according to procedures described in the methodology (section 3-2.4, TenBrook *et al.* 2009a). The final acute and chronic data sets are shown in Tables 3 and 5, respectively. Acceptable acute and chronic data that were excluded, and the reasons for their exclusion, are shown in Tables 4 and 7, respectively.

7. Acute criteria calculation

Acceptable acute toxicity data were available for four of the five required taxa for the application of the species sensitivity distribution (SSD); benthic crustacean data was not available for malathion, and therefore the SSD method could not be used (section 3-3.1, TenBrook *et al.* 2009a). The Assessment Factor (AF) method was used to derive the acute criterion (section 3-3.3, TenBrook *et al.* 2009a). The AF method requires an acceptable acute toxicity value for a species in the family Daphniidae, which was met in the acute toxicity data set. The AF method calculates the criterion by dividing the lowest species mean acute value from the data set by a factor, which is determined by the number of data available. There were acute toxicity values for four species in the data set, and the lowest SMAV in the data set was 1.5 µg/L for *Chironomus tentans* (Belden and Lydy 2000). This value was divided by an assessment factor of 5.1 because there are acceptable data from four taxa (Table 3.13, TenBrook *et al.* 2009a). The acute criterion calculated using the AF represents an estimate of the median 5^{th} percentile value of the SSD, which is the recommended acute value. To calculate the acute criterion from the recommended acute value a safety factor of 2 is applied (section 3-3.3, TenBrook *et al.* 2009a).

Acute criterion = (lowest acute value ÷ assessment factor) ÷ 2
= (1.5 μg/L ÷ 5.1) ÷ 2 = 0.15 μg/L

The use of the SSD with the Burr Type III fitting was not possible due to lack of data for the benthic crustacean taxa requirement. For the sake of comparison, the hypothetical acute criterion obtained by the SSD was calculated with the BurrliOz program (v. 1.0.13; CSIRO 2001) by fitting the available data set to a Burr Type III distribution. The fitting parameters obtained were b = 17.02; c = 0.35; k = 2.46 and the likelihood 236.88.

The resulting 5th percentile with a 50% confidence limit was 1.45 μg/L.

The acute criterion was then calculated as follows:

Acute criterion = 5th percentile (at 50% CI) ÷ 2
= 1.45 μg/L ÷ 2 = 0.73 μg/L

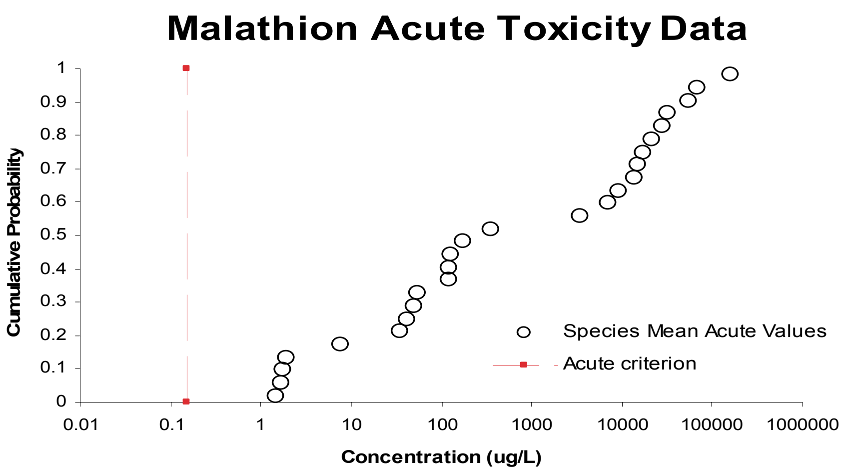
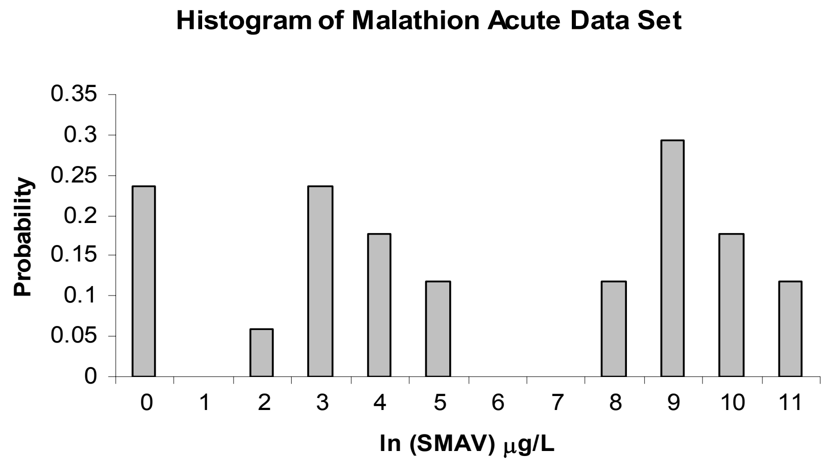


Figure 2. Malathion acute toxicity data set.



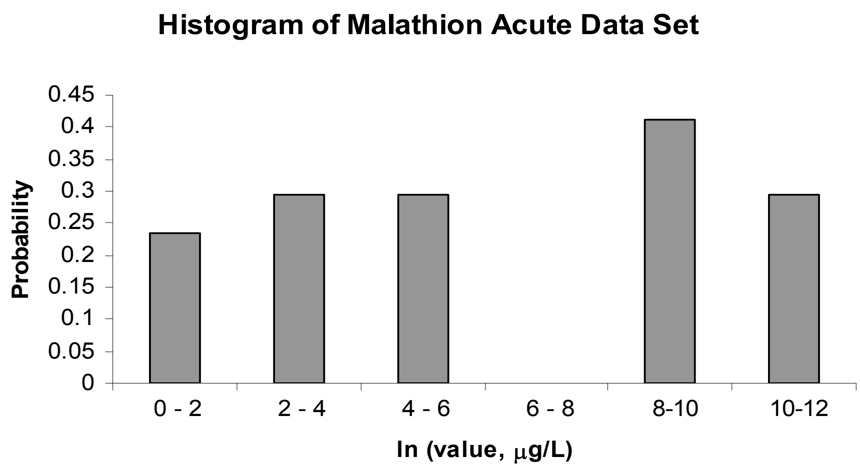


Figure 3. Histograms of the natural logarithm of the acute values for the malathion data set.

8. Chronic criteria calculation

The five taxa requirements could not be met for the chronic species sensitivity distribution (SSD), therefore the chronic criterion was calculated with an acute-to-chronic ratio (ACR; section 3-4.2, TenBrook *et al.* 2009a). The three acute-to-chronic ratios (ACRs) that could be calculated from data were for three fish: 11, bonytail (*Gila elegans);* 4, Colorado squawfish *(Phytocheilus lucius);* and 36, flagfish (*Jordanella floridae)*. The available values were all for fish and did not include an invertebrate, which is required by the methodology, because invertebrates are usually the most sensitive taxa (section 3-4.2, TenBrook *et al.* 2009a). A default ACR of 12.4 was included in the ACR data set to account for an invertebrate (section 3-4.2.2, TenBrook *et al.* 2009a). The species mean acute to chronic ratio (SMACR) was determined by taking the geometric mean of all of the three data-based ACRs and the default ACR. Dividing the previously obtained acute 5th percentile by the SMACR the chronic criterion was determined:

Chronic criterion = Final acute value ÷ SMACR

$= 0.29 \div 11.80 = 0.03\ \mu g/L$

9. Bioavailability

Not many studies on the effects of suspended and dissolved solids on the bioavailability of malathion are available. Ciglasch *et al.* (2008) reported that malathion in the previously unextractable fractions of geosorbents became biodegradable after about 200 hr of incubation. These results suggest that malathion was temporarily incorporated by plants or soil biota and then released upon turnover/decay of these organisms.

In a study that evaluated the effect of the amount of organic matter on the bioavailability of malathion to earthworms (*Lumbricus terrestris*), results suggested that sorption to organic matter was not a limiting factor for malathion bioavailability (Henson-Ramsey *et al.* 2008). According to a study by Olvera-Hernandez *et al.* (2004), malathion did not seem to sorb strongly to the sediment, and was therefore bioavailable. For freshwater snails (*Stagnicola sp.*) the uptake of malathion occurred quickly (up to 0.1 μg/g in 36 hr), indicating that malathion was bioavailable in sediment (Martinez-Tabche *et al.* 2002).

Based on the modest available information, malathion appears to be bioavailable and compliance with criteria should be determined on a total concentration basis.

10. Mixtures

Pesticides occur in the environment most often in mixtures. For mixtures of compounds with a similar mode of action, either the toxic unit or the relative potency factor approach can be used to determine compliance (section 3-5.2, TenBrook *et al.* 2009a). There is no way to account for mixtures of compounds with a different mode of action in compliance determination.

Malathion has been shown to have moderate additive and/or synergistic effects with other acetylcholinesterase (AChE) inhibitors. In a study by Laetz *et al.* (2009) Coho salmon (*Oncorhynchus kisutch*) exposed to combinations of diazinon with malathion and chlorpyrifos with malathion had synergistic, rather than additive effects on AChE activities. Mixtures were designed to produce 50% AChE inhibition based on additive interactions, however, the pairing of diazinon (7.3 μg/L) with malathion (3.7 μg/L) produced severe AChE inhibition (> 90%). Many fish species die after high rates of acute brain AChE inhibition (> 70–90%) (Fulton and Key 2001). While the mixtures of these organophosphates (OPs) with malathion were found to have synergistic toxicity effects, the study did not provide a way to incorporate this interaction quantitatively into compliance. At the same time, in light of the recent dramatic decline of Chinook salmon and the ban on commercial salmon fishing off the coast of California, this finding has possibly very important implications for environmentally relevant concentrations of OPs in mixtures and their toxic effects on endangered Salmonids.

Malathion was shown to produce abnormalities in developing circulatory systems of Japanese killifish embryos. In the same study malathion and carbaryl together produced only slightly greater than additive toxic effects and at the highest concentrations of the two insecticides (40 mg/L of malathion and 5 mg/L of carbaryl) antagonistic effects were noted (Solomon and Weis 1979). In a study by Overmyer *et al.* (2003), mixtures of carbaryl with malathion or chlorpyrifos, and all three pesticides together, showed greater than additive toxicity towards black fly larvae (*Simulium vittatum*). These results are expressed in toxic units (TU) and no synergistic ratios were calculated, so this information cannot be used for compliance determination.

Synergistic toxicity effects were reported by Macek (1975) on bluegill for mixtures of malathion with Baytex, sevin, EPN, Perthane and copper sulfate, whereas additive effects were observed in the case of mixtures with DDT and toxaphene. For midge larvae (*Chironomus tentans*) in a mixture of atrazine and malathion, atrazine did not have any effect on the toxicity of malathion. Synergistic ratio values were equal to 1 for the range of atrazine concentrations (0-200μg/L) investigated. This result shows that there was no difference between the EC_{50} control (without atrazine) and the EC_{50} treatment (in the presence of atrazine) (Belden and Lydy 2000).

The toxicity of malathion on toad larvae (*Bufo arenarum*) was potentiated by the exogenously applied polyamines spermidine and spermine at concentrations of 0.2 mM (Venturino *et al.* 1992). Putrescine and spermidine were shown to synergistically enhance the toxicity of malathion. Polyamines may affect malathion toxicity by altering its rate of absorption, as well as its activation and/or detoxification pathways, but they do not possess the same mode of action for toxicity.

Mixtures of malathion and endrin (nerve membrane toxin) were studied by Hermanutz (1985) in flagfish (*Jordanella floridae*). Investigators reported enhanced toxicity effects “at concentrations not causing death when the pesticides were tested individually”. These two compounds possess independent modes of action and from the data provided in the paper there is currently no way to consider the interaction of these two compounds for compliance determination. Endrin has not been produced or sold for general use in the United States since 1986 therefore the interaction with malathion is not likely to be a problem.

A study by Rawash *et al.* (1975) found that mixtures of malathion with DDT and keltane in the ratio 3:10:5 tested with *Culex pipiens* and *Daphnia magna* had an antagonistic toxicity effect. A malathion concentration of 35 μg/L corresponded to 95% larval mortality for *C. pipiens* but when the same concentration was combined with DDT and kelthane it only induced 50% mortality. The same result was observed for *Daphnia magna*. These compounds possess independent modes of action and from the data provided in the paper there is currently no way to consider the interaction of these compounds for compliance determination.

There is not clear evidence for additive interactions when multiple acetylcholinesterase inhibitors are present, so the concentration addition model cannot be used when malathion is detected with other AChE inhibitors. There are no multi-species coefficients of interaction reported in the literature, so the non-additive interaction model cannot be used to assess water quality criteria compliance.

11. Temperature, pH, other water quality effects

Malathion undergoes hydrolysis in aqueous solutions and reaction products are dependent upon pH of the media. Muhlmann and Schroder (1957) studied the hydrolysis products of malathion and found that in basic solutions (pH > 8) the primary products are diethyl fumarate and dimethyl phosphorodithionic acid. In acid solutions (pH < 5), the products are dimethyl phosphorothionic acid and 2-mercaptodiethylsuccinate. The toxicity of these hydrolysis products to Mudminnows (*Umbra pygmaea*) was studied by Bender (1969a). Results showed that malathion was more toxic than either of the hydrolysis products and that basic hydrolysis products were more toxic than the acid hydrolysis products. The 96 hr LC_{50} values in mg/L were as follows:

malathion - 0.24;
basic hydrolysis products: diethyl fumarate - 8.5; dimethyl phosphorodithioic acid – 17;
acid hydrolysis products: 2-mercaptodiethylsuccinate - 47; dimethyl phosphorothionic acid – 26.

Wolfe *et al.* (1977) found that malathion is stable in water at pH 2.59 for up to 10 days, however, in basic conditions malathion is much more susceptible to basic degradation and significant chemical breakdown. Malathion was shown to have a half-life of 36 hr in water at 27 ^{o}C and pH 8. With increasing temperature at pH 8 a decrease in malathion half-life occurs with $t_{1/2}$ 40 d at 0 ^{o}C to $t_{1/2}$ 1 hr at 40 ^{o}C (Wolfe *et al.* 1977). Other studies have reported the decrease of malathion half-life with increasing temperature from 10.5 d at 20 ^{o}C to 1.3 d at 37.5 ^{o}C (Freed *et al.* 1979).

Work done by Keller and Ruessler (1997) studied the effect of temperature and pH on the toxicity of three species of bivalves, *Utterbackia imbecillis*, *Villosa lienosa* and *Villosa villosa*. Two pH values were studied, pH 7.5 and 7.9, that corresponded to soft water and moderately hard water, respectively. No significant variation in toxicity values was observed for the two pH conditions investigated and for that reason the LC_{50} values at both pH values were considered in the acute dataset. The study of temperature effects on malathion toxicity indicates that malathion toxicity decreases with increasing temperature due to increased degradation.

Although there is evidence of temperature effects on malathion toxicity, data for enough species is not available to adequately quantify the relationship of toxicity with temperature. Data rated relevant and reliable (RR) for at least two species, a fish and an invertebrate, are required to establish this relationship (section 3-5.0, TenBrook *et al.* 2009a). Therefore only results of tests conducted at standard temperatures (i.e., temperatures recommended in standard toxicity test methods) are included in the data set and equations are not needed for criteria expression.

12. Sensitive species

The calculated acute and chronic criteria (0.15 μg/L and 0.03 μg/L, respectively) are below the lowest acute and chronic values in the dataset. The lowest acute value in either the acceptable data set (rated RR), or the supplemental data set (rated RL, LR, or LL) is 0.21 μg/L for *Chironomus riparius* (Hoffman and Fisher 1994). The lowest measured chronic value in either data set is a maximum acceptable toxicant concentration (MATC) of 0.08 μg/L for *Daphnia magna* (Blakemore and Burgess 1990). Both the acute and chronic criteria, as calculated, should be adequately protective based on currently available data from single-species toxicity tests.

13. Bioaccumulation

A chemical has the potential to bioaccumulate if it possesses any of the following characteristics: log $K_{OW} > 3$, molecular weight < 1000, molecular diameter < 5.5 Å, molecular length < 5.5 nm, solid-water partition coefficient (log K_d) > 3 or if it has a high adsorption affinity. Chemicals are not expected to bioaccumulate if they are reactive and/or readily metabolized (EC 1996; OECD 1995).

Malathion has a low log K_{OW} (< 3), and from the studies available it does not appear to bioaccumulate significantly, is readily metabolized and shows high depuration rates. For these reasons malathion is not expected to bioaccumulate significantly.

In fish, data suggests slight bioaccumulation of malathion. For topmouth gudgeon (*Pseudorasbora parva*) the uptake of malathion was very low and its metabolism occurred very rapidly (Kanazawa 1975). Bluegill Sunfish (*Lepomis macrochirus*) was shown to bioaccumulate malathion (log BCF = 2.01), but depuration was shown to occur quickly ($t_{1/2}$ 0.69 d) (Forbis 1994). Tsuda *et al*. (1989) reported that malathion bioaccumulated to some extent (log BCF = 1.54) in the freshwater fish willow shiner (*Gnathopogon caerulescens*), however, the concentration of this chemical in the fish whole body decreased rapidly after 24 – 168 hr. The biological half-life of malathion in willow shiner was 1.4 hr. Malathion uptake occurred in carp (log BCF = 0.65), however, concentrations of malathion in muscle and liver of the fish decreased rapidly (rate of elimination (k_e) = 0.13hr^{-1}), which is indicative of no bioaccumulation (Tsuda *et al.* 1990).

In a study with the water flea (*Simocephalus vetulus*) malathion accumulated slightly, with log BCF values of 2.1 (Olvera-Hernandez *et al.* 2004). The 48 hr LC_{50} for malathion in water was 2.9 μg/L (95% CI, 2.4 - 3.6 μg/L) and in spiked sediments was 3.8 μg/kg (95% CI, 2.1 - 4.4 μg/L) while the log BCF for malathion was 2.1. For the freshwater snail (*Stagnicola sp.*) the uptake of malathion occurred quickly (up to 0.1 μg/g in 36 hr), however, the short elimination half life ($t_{1/2\ e}$ = 46.79 hr) led to the conclusion that this compound is not being stored in snails (Martinez-Tabche *et al.* 2002).

To check that these criteria are protective of terrestrial wildlife that may consume aquatic organisms, a bioaccumulation factor (BAF) is used to estimate the water concentration that would roughly equate to a reported toxicity value for such terrestrial wildlife ($LC_{50,\text{ oral predator}}$). The BAF of a given chemical is the product of the bioconcentration factor (BCF) and a biomagnification factor (BMF), such that BAF=BCF*BMF. The dietary LC_{50} of 1485 mg/kg for mallard and a BCF value of $10^{2.98}$ L/kg for brown shrimp (*Paneaus aztecus*) given by Howard (1991) were used as an example estimation of bioaccumulation in the environment. A default BMF of 1 was chosen based on the log K_{ow} (Table 3.15, TenBrook *et al.* 2009a) because no biomagnification data was found in the literature.

$$NOEC_{water} = \frac{LC_{50,oral\_predator}}{BCF_{food\_item} * BMF_{food\_item}}$$

Mallard: $$NOEC_{water} = \frac{1485\ {}^{mg}\!/_{kg}}{10^{2.98}\ {}^{L}\!/_{kg} * 1} = 1.55\ {}^{mg}\!/_{L} = 1{,}550\ {}^{\mu g}\!/_{L}$$

In this example, the calculated chronic criterion is 51,667- fold below the estimated $NOEC_{water}$ value for wildlife and is not expected to cause adverse effects due to bioaccumulation.

14. Ecosystem and other studies

Several studies were found on the effects of malathion in mesocosms and ecosystems, however, the majority of them rated as non-reliable due to lack of information provided in the studies, such as water quality parameters, lack of replication, controls and concentrations used. The studies that rated as reliable (R) or less reliable (L) are summarized below.

Relyea (2005) tested the effect of malathion on an artificial mesocosm sprayed with a concentration of 0.32 mg/L of a commercial form of malathion (50.6%) for two weeks. Of the tested predators, *Dytiscus sp.* beetles were eliminated ($p=0.05$) from the ecosystem, the survival of the dragonfly *Tramea sp.* was significantly reduced ($p=0.01$) and no diving beetles (*Acilius semisulcatus*) survived. Of the zooplankton tested *Daphnia pulex* was completely absent with malathion ($p<0.001$), eurytemora showed an increased abundance ($p<0.03$) and mesocyclops were unaffected. Of the large herbivores there were no effects on the three snail species tested. Among the tadpoles, survival of leopard frog and wood frog increased but was not significant ($p>0.1$). Malathion reduced the diversity and biomass of the insect predators, completely exterminating Dytiscus beetles and reducing the abundance of *Tramea sp.* and backswimmers (*Notonecta undulata*). Malathion also affected zooplankton by eliminating cladocerans while favoring copepods.

In a study by Kennedy and Walsh (1970), bluegill and channel catfish were exposed to four applications of malathion at two concentrations in ponds over an 11-week summer period. No significant differences were observed in the growth of the fish between treated and untreated systems at the two concentrations tested, 0.002 mg/L and 0.02 mg/L. The effects of malathion exposure on aquatic insects in those same ponds was also evaluated. The total number of aquatic insects in the 0.002 mg/L treated pond was not significantly different from the control, whereas for the 0.02 mg/L treated pond that number was significantly different from both the low-concentration treated and the control ponds. The benthic invertebrate population in the 0.02 mg/L treated ponds was affected by the exposure to malathion. Chironomidae and baetid mayflies, which made up 70% and 24% of the total benthos, respectively, showed a significant reduction in numbers after three applications. Heptageniid mayflies, which made up 5% of the benthos, did not recover after application of malathion. No measurable effects were observed in fish at the applied concentrations in these ponds.

These studies applied malathion at concentrations well above the derived criteria and did not calculate ecosystem-level NOEC values. Based on this limited information, it appears that an acute criterion of 0.15 μg/L and a chronic criterion of 0.03 μg/L will be protective of organisms in ecosystems. These results are not entirely conclusive because, as discussed in section 9, the potential effects of suspended and dissolved solids in natural waters on malathion bioavailability cannot be predicted.

15. Threatened and endangered species

Current lists of state and federally listed threatened and endangered animal species in California were obtained from the California Department of Fish and Game web site (Department of Fish and Game 2009). The species *Oncorhynchus mykiss, Oncorhynchus clarki*, *Oncorhynchus kisutch* and *Oncorhynchus tshawytscha* are all listed as federally endangered or threatened in California. The data set used to calculate the acute criterion includes values for all these species, indicating that the determined acute criterion of 0.15 μg/L should be protective of these species. No threatened or endangered species are listed in the supplemental data. Of the endangered species not present in the data set there were no appropriate surrogates available to predict toxicity values.

Based on the available data there is no evidence that the calculated acute and chronic criteria will be underprotective of threatened and endangered species. The information in this assessment is limited because for the most sensitive species in the data set, the crustaceans and insects, there is no information on the effects of malathion on federally endangered crustaceans or insects, or acceptable surrogates (i.e., in the same family). No single species plant studies were found for criteria derivation, so no estimation could be made about plants on the state of federal endangered, threatened or rare species lists. Based on the mode of action, plants should be relatively insensitive to malathion and the calculated criteria should be protective.

16. Harmonization with air and sediment criteria

This section addresses how the maximum allowable concentration of malathion might impact life in other environmental compartments through partitioning. However, there are no federal or state sediment or air quality standards for malathion (California Air Resources Board 2008; California Department of Water Resources 1995; USEPA 2009a; USEPA 2009b) to enable this kind of extrapolation. For biota, the limited data on bioconcentration or biomagnification of malathion is addressed in section 13.

17. Assumptions and limitations

The assumptions, limitations, and uncertainties involved in criteria generation are available to inform environmental managers of the accuracy and confidence in criteria. Chapter 2 of the methodology (TenBrook *et al.* 2009a) discusses these points for each section as different procedures were chosen, such as the list of assumptions associated with using an SSD, included in section 2-3.1.5.1, and reviews them in section 2-7.0. This section summarizes any data limitations that affected the procedure used to determine the final malathion criteria.

Lack of data was the most important limitation in both the acute and chronic data sets for malathion. In the acute data set the taxa requirement for the benthic crustacean was not met which precluded the use of an SSD. The same was true for the chronic data set where several taxa requirements were not met and therefore an ACR was used to derive the chronic criterion (see section 8). The final acute criterion was derived using an assessment factor procedure (see section 7).

18. Comparison to National standard methods

In this section we aim to develop acute and chronic criteria using the EPA 1985 methods for the data set generated for malathion in this report. The following taxonomic information is required for the derivation of acute or chronic criteria by the SSD method (minimum of 8 acute or chronic data) according to the USEPA (1985) method.

a. The family Salmonidae in the class Osteichthyes; criteria met with *Oncorhynchus kisutch*
b. One other family (preferably a commercially or recreationally important, warm water species) in the class Osteichthyes; met with *Jordanella floridae*
c. A third family in the phylum Chordata; met with *Pimephales promelas*
d. A planktonic crustacean; met with *Ceriodaphnia dubia*
e. A benthic crustacean; criteria not met
f. An insect; met with *Chironomus tentans*, family Chironomidae
g. A family in a phylum other than Arthropoda or Chordata; met with *Villosa lienosa* in the phylum Mollusca
h. A family in any order of insect or any phylum not already represented; criteria met with *Acroneuria pacifica* an insect in the Perlidae family

The EPA method could not be used to calculate an acute criterion for malathion since one of the taxa requirements is not available. This calculation was done merely as a comparison to the results obtained using the new methodology (described in Chapters 2 and 3, TenBrook *et al.* 2009a). Criteria were calculated using the Log-triangular (log T) distribution following the EPA 1985 guidelines with the malathion data set from Table 2 with 26 species values. It is worth noting that the EPA method uses genus mean acute values whereas species mean acute values are reported in Table 2. Calculations were done with both genus and species mean values, however, criterion did not differ significantly. Presented next are the results obtained using the previously shown data set (using species mean values).

Example Acute value by log T distribution (5th percentile value) = 1.57
Example Acute Criterion = acute value ÷ 2
= 1.57 μg/L ÷ 2 = 0.79 μg/L

For the chronic criterion, the malathion data consisted of five species, a daphnid and four fish, which do not fulfill the taxa requirements. Due to data limitation no chronic value can be calculated using EPA 1985 methods.

The current EPA aquatic life benchmark values for malathion are as follows:

Fish: 0.295 μg/L (Acute) and 0.014 μg/L (Chronic)

Invertebrates: 0.005 μg/L (Acute) and 0.000026 μg/L (Chronic)

These values were calculated based on the lowest 96-hour LC_{50} values for acute tests or lowest NOEC from a life-cycle or early life stage test for chronic tests in standardized tests. These tests were usually with rainbow trout, fathead minnow, or bluegill for fish and midge, scuds, or daphnids for invertebrates. The fish benchmark values are similar to the acute (0.15 μg/L) and chronic (0.03 μg/L) criteria calculated using the methodology, however, the invertebrate benchmark values are significantly lower. The data used to calculate these benchmark values are based on the studies by Rawash *et al.* (1975) and Wong *et al.* (1995) which presented an LC_{50} of 0.01 μg/L and a LOEC of 0.01 μg/L, respectively. Both these studies rated LN (low relevance, non-reliable) using the methodology rating guidelines. The reason for low relevance scores was due to the non-use of an acceptable standard, non-reporting of chemical purity, and no description/use of controls. The reliability scores were very low due to the lack of information on the study conditions such as water quality parameters and statistic methods used. For these reasons we believe that these studies should not be included in criteria calculations and furthermore that the criteria calculated using the described methodology are more reliable and robustly calculated than the EPA benchmarks.

19. Final criteria statement

The final criteria statement is:

Aquatic life in the Sacramento River and San Joaquin River basins should not be affected unacceptably if the four-day average concentration of malathion does not exceed 0.03 μg/L more than once every three years on the average and if the one-hour average concentration does not exceed 0.15 μg/L more than once every three years on average.

Acknowledgements

This project was funded through a contract with the Central Valley Regional Water Quality Control Board of California. Mention of specific products, policies, or procedures do not represent endorsement by the Regional Board.

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Data Tables

Table 3. Final acute toxicity data set for malathion. All studies were rated RR and were conducted at standard temperature. Values in bold are species mean acute values. S: static; SR: static renewal; FT: flow-through.

Species	Common identifier	Family	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference
Acroneuria pacifica	Stonefly	Perlidae	FT	Nom	95%	96 h	12.8	Mortality	Naiads	**7.7**	Jensen & Gaufin 1964b
Anisops sardeus	Insect	Notonectidae	S	Nom	>99%	48 h	27	Immobility /Mortality	Adult	**42.2 (40.5-44.9)**	Lahr *et al.* 2001
Ceriodaphnia dubia	Cladoceran	Daphniidae	S	Nom	99.2%	48 h	25	Mortality	≤ 24 h	3.35 (2.68-3.93)	Maul *et al.* 2006
Ceriodaphnia dubia	Cladoceran	Daphniidae	S	Nom	97%	48 h	25	Mortality	≤ 24 h	1.14 (1.04-0.25)	Nelson & Roline 1998
Geomean										**1.95**	
Chironomus tentans	Midge	Chironomidae	S	Meas	98%	96 h	20	Immobility /Mortality	4th instar	**1.5 (1.2–1.9)**	Belden & Lydy 2000
Daphnia magna	Cladoceran	Daphniidae	S	Nom	Analytical	48 h	21	Immobility /Mortality	< 24 h	**1.8 (1.5-2.0)**	Kikuchi *et al.* 2000
Elliptio icterina	Bivalve	Unionidae	S	Nom	96%	96 h	25	Mortality	Juvenile	**32000**	Keller and Ruessler 1997
Gambusia affinis	Mosquito fish	Poeciliidae	S	Nom	> 90 %	48 h	27	Mortality	5 d	**3440 (2720-4370)**	Teitze *et al.* 1991
Gila elegans	Bonytail	Cyprinidae	SR	Meas	93%	96 h	22	Mortality	6 d	**15300**	Beyers *et al.* 1994
Jordanella floridae	Flagfish	Cyprinodonti-dae	FT	Meas	95%	96 h	24.4-25.2	Mortality	33 d	**349**	Hermanutz 1978
Lampsilis siliquoidea	Bivalve	Unionidae	S	Nom	96%	48 h	25°C / pH7.5	Mortality	Glochidia	**7000**	Keller and Ruessler 1997
Lampsilis subangulata	Bivalve	Unionidae	S	Nom	96%	96 h	25°C / pH7.5	Mortality	Juvenile	**28000**	Keller and Ruessler 1997
Megalonaias nervosa	Bivalve	Unionidae	S	Nom	96%	24 h	25°C / pH7.5	Mortality	Glochidia	**22000**	Keller and Ruessler 1997
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	11 d	16 (13-19)	Fujimura *et al.* 1991

Species	Common identifier	Family	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	45 d	25 (19-34)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	29 d	12 (11-14)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	13 d	64 (55-77)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	45 d	100 (87-150)	Fujimura *et al.* 1991
Morone saxatilis	Stripped bass	Moronidae	FT	Meas	94.2%	96 h	15-17	Mortality	45 d	66 (58-74)	Fujimura *et al.* 1991
Geomean										**36**	
Neomysis mercedis	Mysid	Mysidae	FT	Meas	94.2%	96 h	17	Mortality	Neonates: ≤ 5d	2.2 (2.0-2.5)	Brandt et al 1993
Neomysis mercedis	Mysid	Mysidae	FT	Meas	94.2%	96 h	17	Mortality	Neonates: ≤ 5d	1.5 (1.2-1.8)	Brandt et al 1993
Neomysis mercedis	Mysid	Mysidae	FT	Meas	94.2%	96 h	17	Mortality	Neonates: ≤ 5d	1.4 (1.3-1.5)	Brandt et al 1993
Geomean										**1.7**	
Oncorhynchus clarki	Cutthroat trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	0.33	Test 1: 150 (133-170)	Post & Schroeder 1971
Oncorhynchus clarki	Cutthroat trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	1.25g	Test 2: 201 (175-231)	Post & Schroeder 1971
Geomean										**174**	
Oncorhynchus kisutch	Coho salmon	Salmonidae	SR	Nom	95%	96 h	13	Mortality	1.7 g	**130 (208-388)**	Post & Schroeder 1971
Oncorhynchus mykiss	Rainbow trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	0.41g	**122 (98-153)**	Post & Schroeder 1971
Pimephales promelas	Fathead minnow	Cyprinidae	FT	Meas	95%	96 h	25	Mortality	29-30 d; 0.069 g; 1.7 cm	**14100 (12300-16100)**	Geiger *et al.* 1984
Pteronarcys californica	Stonefly	Pteronarcyidae	S	Nom	95%	96 h	11.5	Mortality	Naiads, 4-6 cm	**50**	Jensen & Gaufin 1964a

Species	Common identifier	Family	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference
Ptychocheilus lucius	Colorado squawfish	Cyprinidae	SR	Meas	93%	96 h	22	Mortality	26d	**9140**	Beyers *et al.* 1994
Rana palustris	Pickerel Frog	Ranidae	S	Meas	98%	48 h	16.5	Mortality	Tadpole, Gosner 26	**17100**	Budischak *et al.* 2009
Salvelinus fontinalis	Brook trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	Test 1: 1.15g	Test 1: 130 (110-154)	Post & Schroeder 1971
Salvelinus fontinalis	Brook trout	Salmonidae	SR	Nom	95%	96 h	13	Mortality	Test 2: 2.13 g	Test 2: 120 (96-153)	Post & Schroeder 1971
Geomean										**125**	
Simulium vittatum	Black fly	Simuliidae	S	Meas	98%	48 h	21	Mortality	6th & 7th instar	**54.20 (44.70-66.43)**	Overmyer *et al.* 2003
Streptocephalus sudanicus	Crustacean	Streptocepha-lidae	S	Nom	>99%	48 h	27	Immobility /Mortality	Adult	**67750 (52220-90300)**	Lahr *et al.* 2001
Villosa lienosa	Bivalve	Unionidae	S	Nom	96%	24 h	25	Mortality	Glochidia	**54000**	Keller and Ruessler 1997
Villosa villosa	Bivalve	Unionidae	S	Nom	96%	96 h	32°C / pH7.5	Mortality	Juvenile	180000	Keller and Ruessler 1997
Villosa villosa	Bivalve	Unionidae	S	Nom	96%	96 h	32°C / pH7.9	Mortality	Juvenile	142000	Keller and Ruessler 1997
Geomean										**159875**	

Table 4. Acceptable acute data excluded in data reduction process.

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (μg/L)	Reference	Reason for exclusion
Acroneuria pacifica	Stonefly	S	Nom	95%	24 h	11.5	Mortality	Naiads, 2-2.5 cm	12	Jensen & Gaufin 1964a	2,5
Acroneuria pacifica	Stonefly	S	Nom	95%	48 h	11.5	Mortality	Naiads, 2-2.5 cm	16	Jensen & Gaufin 1964a	2,5
Acroneuria pacifica	Stonefly	S	Nom	95%	96 h	11.5	Mortality	Naiads, 2-2.5 cm	7	Jensen & Gaufin 1964a	5
Anisops sardeus	Insect	S	Nom	>99%	24 h	27	Immobility /Mortality	Adult	70.7 (57.4-78.0)	Lahr *et al.* 2001	2
Ceriodaphnia dubia	Cladoceran	S	Nom	97%	24 h	25	Mortality	≤ 24 h	3.18 (2.36-4.27)	Nelson & Roline 1998	2
Chironomus tentans	Midge	S	Nom	99%	96 h	20	Immobility /Mortality	4th instar	19.09	Pape-Lindstrom & Lydy 1997	1
Elliptio icterina	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	61000	Keller and Ruessler 1997	2
Elliptio icterina	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	54000	Keller and Ruessler 1997	2
Elliptio icterina	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	50000	Keller and Ruessler 1997	2
Gambusia affinis	Mosquito fish	S	Nom	> 90 %	24 h	27	Mortality	5 d	12680 (12110-13200)	Teitze *et al.* 1991	2
Jordanella floridae	Flagfish	FT	Meas	95%	9 d	24.4-25.2	Mortality	33 d	235	Hermanutz 1978	2
Jordanella floridae	Flagfish	FT	Meas	95%	7 d	23.4-24.5	Mortality	37 d	320 (24hr)	Hermanutz 1985	2
Jordanella floridae	Flagfish	FT	Meas	95%	7d	23.4-24.5	Mortality	37 d	280 (48hr)	Hermanutz 1985	2
Lampsilis siliquoidea	Bivalve	S	Nom	96%	24 h	25°C / pH 7.9	Mortality	Glochidia	8000	Keller and Ruessler 1997	2

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Lampsilis siliquoidea	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Glochidia	8000	Keller and Ruessler 1997	2
Lampsilis subangulata	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	43000	Keller and Ruessler 1997	2
Lampsilis subangulata	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	32000	Keller and Ruessler 1997	2
Lampsilis subangulata	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	32000	Keller and Ruessler 1997	2
Neyomysis mercedis	Mysid/ Crustacean	FT	Meas	94.2%	96 h	17	Mortality	Juveniles: > 15d	3.8 (2.9-5.3)	Brandt et al 1993	3
Oncorhynchus clarki	Cutthroat trout	SR	Nom	95%	24 h	13	Mortality	0.33	Test 1: 200 (163-245)	Post & Schroeder 1971	2
Oncorhynchus kisutch	Coho salmon	SR	Nom	95%	24 h	13	Mortality	1.7 g	300 (211-346)	Post & Schroeder 1971	2
Oncorhynchus mykiss	Rainbow trout	SR	Nom	95%	24 h	13	Mortality	0.41g	240 (198-291)	Post & Schroeder 1971	2
Oncorhynchus mykiss	Rainbow trout	SR	Nom	95%	48 h	13	Mortality	0.41g	196 (165-223)	Post & Schroeder 1971	2
Oncorhynchus mykiss	Rainbow trout	SR	Nom	95%	72 h	13	Mortality	0.41g	175 (146-209)	Post & Schroeder 1971	2
Pteronarcys californica	Stonefly	S	Nom	95%	24 h	11.5	Mortality	Naiads, 4-6 cm	180	Jensen & Gaufin 1964a	2
Pteronarcys californica	Stonefly	S	Nom	95%	48 h	11.5	Mortality	Naiads, 4-6 cm	72.5	Jensen & Gaufin 1964a	2
Salvelinus fontinalis	Brook trout	SR	Nom	95%	72 h	13	Mortality	Test 1: 1.15g	Test 1: 160 (144-182)	Post & Schroeder 1971	2
Salvelinus fontinalis	Brook trout	SR	Nom	95%	72 h	13	Mortality	Test 2: 2.13 g	Test 2: 150 (104-216)	Post & Schroeder 1971	2

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Utterbackia imbecillis	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Glochidia	366000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Glochidia	324000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	24 h	32°C / pH 7.5	Mortality	Glochidia	366000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	568000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	365000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	295000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	96 h	25°C / pH7.5	Mortality	Juvenile	215000	Keller and Ruessler 1997	7
Utterbackia imbecillis	Bivalve	S	Nom	96%	24 h	25°C / pH 7.9	Mortality	Juvenile	667000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	48 h	25°C / pH 7.9	Mortality	Juvenile	363000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	72 h	25°C / pH 7.9	Mortality	Juvenile	262000	Keller and Ruessler 1997	2, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	96 h	25°C / pH7.9	Mortality	Juvenile	219000	Keller and Ruessler 1997	7
Utterbackia imbecillis	Bivalve	S	Nom	96%	24 h	32°C / pH 7.5	Mortality	Juvenile	391000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	48 h	32°C / pH 7.5	Mortality	Juvenile	280000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	72 h	32°C / pH 7.5	Mortality	Juvenile	165000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	96 h	32°C / pH 7.5	Mortality	Juvenile	40000	Keller and Ruessler 1997	6

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	LC_{50}/ EC_{50} (µg/L)	Reference	Reason for exclusion
Utterbackia imbecillis	Bivalve	S	Nom	96%	24 h	32°C / pH 7.9	Mortality	Juvenile	341000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	48 h	32°C / pH 7.9	Mortality	Juvenile	196000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	72 h	32°C / pH 7.9	Mortality	Juvenile	161000	Keller and Ruessler 1997	6, 7
Utterbackia imbecillis	Bivalve	S	Nom	96%	96 h	32°C / pH 7.9	Mortality	Juvenile	74000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	24 h	25°C / pH 7.5	Mortality	Juvenile	463000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	48 h	25°C / pH 7.5	Mortality	Juvenile	192000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	72 h	25°C / pH 7.5	Mortality	Juvenile	140000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	96 h	25°C / pH 7.5	Mortality	Juvenile	111000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.9	Mortality	Juvenile	181000	Keller and Ruessler 1997	1
Villosa lienosa	Bivalve	S	Nom	96%	72 h	32°C / pH 7.9	Mortality	Juvenile	154000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	96 h	32°C / pH 7.9	Mortality	Juvenile	109000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	24 h	32°C / pH 7.5	Mortality	Juvenile	263000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.5	Mortality	Juvenile	160000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	72 h	32°C / pH 7.5	Mortality	Juvenile	96000	Keller and Ruessler 1997	6
Villosa lienosa	Bivalve	S	Nom	96%	96 h	32°C / pH 7.5	Mortality	Juvenile	74000	Keller and Ruessler 1997	6

Species	**Common identifier**	**Test type**	**Meas /Nom**	**Chemical grade**	**Duration**	**Temp (°C)**	**Endpoint**	**Age/size**	**LC_{50}/ EC_{50} (µg/L)**	**Reference**	**Reason for exclusion**
Villosa villosa	Bivalve	S	Nom	96%	24 h	32°C / pH 7.9	Mortality	Glochidia	117000	Keller and Ruessler 1997	
Villosa villosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.9	Mortality	Glochidia	119000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	24 h	32°C / pH 7.5	Mortality	Juvenile	326000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.5	Mortality	Juvenile	220000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	72 h	32°C / pH 7.5	Mortality	Juvenile	199000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	24 h	32°C / pH 7.9	Mortality	Juvenile	431000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	48 h	32°C / pH 7.9	Mortality	Juvenile	354000	Keller and Ruessler 1997	6
Villosa villosa	Bivalve	S	Nom	96%	72 h	32°C / pH 7.9	Mortality	Juvenile	255000	Keller and Ruessler 1997	6

1. More sensitive endpoint available
2. Later time point result available
3. More sensitive life-stage available
4. Test with measured concentrations available
5. Flow-through test available
6. Test with standard condition available (temperature or pH)
7. Concentration above solubility limit

Table 5. Final chronic toxicity data set for malathion. All studies were rated RR and were conducted at standard temperature. SR: static renewal; FT: flow-through.

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/size	NOEC (µg/L)	LOEC (µg/L)	MATC (µg/L)	Reference
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Length/ Weight	Eggs	630	1250	887	Nguyen & Janssen 2002
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Length	Eggs, 3-5 h old	1250	2500	1768	Lien et al 1997
Geomean											**1252**	
Daphnia magna	Daphnia magna	FT	Meas	94%	21 d	20	Mortality	1st instar <24hr	0.06	0.1	**0.077**	Blakemore & Burgess 1990
Gila elegans	Bonytail	FT	Meas	93%	32 d	22	Growth	48 d	990	2000	**1407**	Beyers *et al.* 1994
Jordanella floridae	Flagfish	FT	Meas	95%	30 d	25.1-25.4	Growth	1-2 d	8.6	10.9	**9.68**	Hermanutz 1978
Lepomis macrochirus	Bluegill	FT	Meas	95%	10 mon	9-29	Mortality	8 cm, 12 g, 1.5 yr	7.4	14.6	10.4	Eaton 1970
Oncorhynchus mykiss	Rainbow trout	FT	Meas	94%	97 d	7.8-13.6	Mortality	eggs 8hr post fert.	21	44	**30.4**	Cohle 1989
Ptychocheilus lucius	Colorado squawfish	FT	Meas	93%	32 d	22	Growth	41 d	1680	3510	2428	Beyers *et al.* 1994
Ptychocheilus lucius	Colorado squawfish	FT	Meas	93%	32 d	22	Mortality	41 d	1680	3510	2428	Beyers *et al.* 1994
Geomean											**2428**	

Table 6. Calculation of the final acute-to-chronic ratio. Values in bold were used in the calculation.

Species	Common identifier	LC_{50} (µg/L)	Reference	Chronic Endpoint	MATC (µg/L)	Reference	ACR (LC_{50}/MATC)
Gila elegans	Bonytail	15300	Beyers *et al.* 1994	Growth	1407	Beyers *et al.* 1994	**10.8**
Jordanella floridae	Flagfish	349	Hermanutz 1978	Growth	9.68	Hermanutz 1978	**36.0**
Ptychocheilus lucius	Colorado squawfish	9140	Beyers *et al.* 1994	Growth	2428	Beyers *et al.* 1994	**3.7**
Invertebrate	*Default ACR*						**12.4**
						Final ACR	**11.8**

Table 7. Acceptable chronic data excluded in data reduction process.

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/ size	NOEC (μg/L)	LOEC (μg/L)	MATC (μg/L)	Reference	Reason for exclusion
Acroneuria pacifica	Stonefly	FT	Nom	95%	30 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	3
Acroneuria pacifica	Stonefly	FT	Nom	95%	5 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2
Acroneuria pacifica	Stonefly	FT	Nom	95%	10 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2
Acroneuria pacifica	Stonefly	FT	Nom	95%	15 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2
Acroneuria pacifica	Stonefly	FT	Nom	95%	20 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2
Acroneuria pacifica	Stonefly	FT	Nom	95%	25 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Survival	Eggs	1250	2500	1768	Nguyen & Janssen 2002	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Survival	Eggs	1250	2500	1768	Nguyen & Janssen 2002	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Mortality	Eggs, 3-5 h old	2500	5000	3536	Lien et al 1997	2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5 d	27	Length	Eggs, 3-5 h old	1250	2500	1768	Lien et al 1997	2
Gila elegans	Bonytail	FT	Meas	93%	32 d	22	Survival	48d	2000	4060	2849	Beyers *et al.* 1994	1
Jordanella floridae	Flagfish	FT	Meas	95%	30 d	25.1-25.4	Survival	1-2d	19.3	24.7	21.83	Hermanutz 1978	1
Jordanella floridae	Flagfish	FT	Meas	95%	140 d	24.1-25.5	Growth	2-3d	13.8 (30d)	18.5 (30d)	15.98 (30d)	Hermanutz 1985	1
Pteronarcys californica	Stonefly	FT	Nom	95%	30 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	3
Pteronarcys californica	Stonefly	FT	Nom	95%	15 d	12.8	Mortality	Naiads	--------	--------	--------	Jenmsen & Gaufin 1964b	2

Species	Common identifier	Test type	Meas /Nom	Chemical grade	Duration	Temp (°C)	Endpoint	Age/ size	NOEC (μg/L)	LOEC (μg/L)	MATC (μg/L)	Reference	Reason for exclusion
Pteronarcys californica	Stonefly	FT	Nom	95%	20 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2
Pteronarcys californica	Stonefly	FT	Nom	95%	25 d	12.8	Mortality	Naiads	--------	--------	--------	Jensen & Gaufin 1964b	2

1. More sensitive endpoint available
2. More sensitive timepoint available
3. No NOEC, LOEC or MATC determined

Table 8. Supplemental studies excluded from criteria derivation (rated RL, LR, or LL). S = static, SR = static renewal, FT = flow-through

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Acroneuria pacifica	Stonefly	FT	Nom	95%	30d/12.8	Mortality	Naiads	--------	0.71	Jensen & Gaufin 1964b	LR 6
Alonella sp	Cladoceran	S	Nom	56%	48h/21	Mortality	NR	2.0 (1.5-2.51)	--------	Naqvi & Hawkins 1989	LL 1,7
Ambystoma mexicanum	Salamander	SR	Meas	99%	96h/20	Mortality	Early larvae, stage L44	20000-25000	--------	Robles-Mendoza *et al.* 2009	LR 6
Ambystoma mexicanum	Salamander	SR	Meas	99%	96h/20	Embryo development	Early larvae, stage L44	--------	LOEC 10000	Robles-Mendoza *et al.* 2009	LR 6
Ambystoma mexicanum	Salamander	SR	Nom	99%	96h/20	Mortality	embryos	-------		Robles-Mendoza et al 2009	LL 5,6
Ambystoma mexicanum	Salamander	SR	Nom	99%	96h/20	Mortality	larvae	--------		Robles-Mendoza et al 2009	LL 5,6
Anabaena fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Growth inhibition	NR	--------	22361	Tandon *et al.* 1988	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	24h/22	Mortality	larvae	25000 (22370-27900)	--------	Varanka 1986	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	48h/22	Mortality	larvae	2030 (1820-2270)	--------	Varanka 1986	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	72h/22	Mortality	larvae	210 (180-250)	--------	Varanka 1986	RL 7
Anodonta anatina	Bivalve	S	Nom	95%	96h/22	Mortality	larvae	80 (50-140)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	24h/22	Mortality	larvae	43800 (39600-48500)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	48h/22	Mortality	larvae	10210 (9410-11360)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	72h/22	Mortality	larvae	3260 (2960-3460)	--------	Varanka 1986	RL 7
Anodonta cygnea	Bivalve	S	Nom	95%	96h/22	Mortality	larvae	310 (280-360)	--------	Varanka 1986	RL 7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Anopheles quadrimaculatus	Insect	S	Nom	NR	48h/32	Mortality	2nd and 3rd instar	1	--------	Milam *et al.* 2000	LL 1,4,7
Asellus brevicaudus	Insect	S	Nom	Technical	24h/21	Mortality	Mature	6000.0	--------	Sanders 1972	RL 7
Asellus brevicaudus	Insect	S	Nom	Technical	96h/21	Mortality	Mature	3000.0	--------	Sanders 1972	RL 7
Atherix	Insect	S	NR	95%	96h/21	Mortality	Mature	385 (246-602)	--------	Johnson & Finley 1980	LL 4,7
Aulosira fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Growth inhibition	NR	--------	LOEC 10000	Tandon *et al.* 1988	LL 6,7
Aulosira fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Photosyn-thesis	NR	--------	22361	Tandon *et al.* 1988	LL 2,7
Aulosira fertilissima	Bluegreen algae	NR	NR	95%	30d/29	Nitrogenase activity	NR	--------	LOEC 10000	Tandon *et al.* 1988	LL 2,6,7
Brachionus calyciflorus	Rotifer	S	Nom	95%	24h/25	Mortality	Newly hatched	33720	--------	Fernández-Casalderry *et al.* 1992	RL 7
Brachionus plicatilis	Rotifer	S	Nom	50%	24h/25	Mortality	Neonates	35300	--------	Snell & Persoone 1989	LL 1,7
Bufo americanos	American toad	SR	Nom	50%	16d/20.1-20.3	Mortality	tadpole (stage 25)	5900	--------	Relyea 2004	LL 1,4
Carassius auratus	Goldfish	FT	Meas	NR	4d/18.2-25.8	Mortality	1-2 h old eggs	2610 (2250-3080)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	FT	Meas	NR	4d/18.2-25.8	Mortality	1-2 h old eggs	3159 (2810-3560)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	FT	Meas	NR	8d/18.2-25.8	Mortality	1-2 h old eggs	1200 (1060-1350)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	FT	Meas	NR	8d/18.2-25.8	Mortality	1-2 h old eggs	1650 (1500-1800)	--------	Birge et al 1979	LR 1
Carassius auratus	Goldfish	S	NR	95%	96h/18	Mortality	0.9 g	10700 (8340-13800)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Ceratopsyche slossonae	Caddisfly	FT	Nom	96.7%	20d/15.6	net spinning /AChE act	4th instar larvae	0.11-0.28	--------	Tessier et al 2000	LL 2
Channa gachu	Snakehead fish	S	Nom	50%	24h/24 ± 2, pH 7.5	Mortality	140 ±10 mm	9200	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/24 ± 2, pH 7.5	Mortality	140 ±10 mm	8100	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/24 ± 2, pH 7.5	Mortality	140 ± 10 mm	7900	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/24 ± 2, pH 7.5	Mortality	140 ±10 mm	7600	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	24h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	8800	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	7950	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	7600	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/35 ± 3, pH 7.5	Mortality	140 ±10 mm	7350	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	24h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	8700	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	7850	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	7300	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/24 ± 2, pH 8.4	Mortality	140 ±10 mm	7050	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	24h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	8750	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	48h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	8000	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	72h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	7650	--------	Dalela et al 1978	LL 1,7
Channa gachu	Snakehead fish	S	Nom	50%	96h/24 ± 2, pH 7.5	Mortality	110 ±10 mm	6950	--------	Dalela et al 1978	LL 1,7
Channa	Snakehead	SR	Nom	Technical	24h/18	Mortality	59.8 g,	9.48	--------	Haider &	LL

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (^oC)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
punctatus	fish						19 cm	(8.59-10.47)		Inbaraj 1986	7
Channa punctatus	Snakehead fish	SR	Nom	Technical	48h/18	Mortality	59.8 g, 19 cm	6510 (5740-7307)	--------	Haider & Inbaraj 1986	LL 7
Channa punctatus	Snakehead fish	SR	Nom	Technical	72h/18	Mortality	59.8 g, 19 cm	5240 (4770-5770)	--------	Haider & Inbaraj 1986	LL 7
Channa punctatus	Snakehead fish	SR	Nom	Technical	96h/18	Mortality	59.8 g, 19 cm	4600 (4220-5020)	--------	Haider & Inbaraj 1986	LL 7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	111.7	--------	Hoffman 1995, Hoffman & Fisher1994	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	191.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	240.3	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	206.4	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	139.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	118.2	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	124.3	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	115.2	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	191	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	142.1	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	74.9	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	150	--------	Hoffman 1995	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	225.6	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	206.1	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	128.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	124.5	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	127.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	130.7	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.44	--------	Hoffman 1995, Hoffman & Fisher1994	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.362	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.324	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.375	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.362	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.212	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.444	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.499	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.437	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.324	--------	Hoffman 1995	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.481	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.571	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.457	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.423	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.3	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.34	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.39	--------	Hoffman 1995	LL 4,7
Chironomus riparius	Midge	S	Nom	97%	24h/22	Immobility/ Mortality	4th instar	0.37	--------	Hoffman 1995	LL 4,7
Cirrhina mrigala	Asian carp	SR	Nom	50%	96h/23	Mortality	4 d, 0.051g	880	--------	Verma *et al.* 1984	LL 1,4
Cirrhina mrigala	Asian carp	SR	Nom	50%	60d/23	Growth	4 d, 0.051g	--------	56.9	Verma *et al.* 1984	LL 1,4
Claassenia	Insect	S	NR	95%	96h/21	Mortality	Second year class	2.6 (1.4-4.3)	--------	Johnson & Finley 1980	LL 4,7
Claassenia sabulosa	Stonefly	S	Nom	Technical	96h/15.5	Mortality	15-20mm	24hr LC50 13 (9.6-17)	--------	Sanders and Cope 1968	LL 4,9
Claassenia sabulosa	Stonefly	S	Nom	Technical	96h/15.5	Mortality	15-20mm	48hr LC50 6.0 (4.1-8.7)	--------	Sanders and Cope 1968	LL 4,9
Claassenia sabulosa	Stonefly	S	Nom	Technical	96h/15.5	Mortality	15-20mm	96hr LC50 2.8 (1.8-4.3)	--------	Sanders and Cope 1968	LL 4,9
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Larval mortality	eggs, 2-4 cell stage	3420 (2910-4010)	--------	Nguyen & Janssen 2001	LL 4
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Embryo mortality	eggs, 2-4 cell stage	--------	LOEC >5000	Nguyen & Janssen 2001	LL 4,6
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Hatching	eggs, 2-4 cell stage	--------	LOEC >5000	Nguyen & Janssen 2001	LL 4,6

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Larval mortality	eggs, 2-4 cell stage	--------	LOEC =2500	Nguyen & Janssen 2001	LL 4,6
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Abnormality	eggs, 2-4 cell stage	--------	900	Nguyen & Janssen 2001	LL 4,2
Clarias gariepinus	Airbreathing catfish	SR	Nom	98%	5d/27	Growth	eggs, 2-4 cell stage	--------	900	Nguyen & Janssen 2001	LL 4
Colisa fasciatus	Gourami fish	SR	Nom	94%	24h/23	Mortality	2.4 g	3150 (2930-3490)	--------	Singh *et al.* 2004	LL 3,4,7
Colisa fasciatus	Gourami fish	SR	Nom	94%	48h/23	Mortality	2.4 g	2850 (2670-3070)	--------	Singh *et al.* 2004	LL 3,4,7
Colisa fasciatus	Gourami fish	SR	Nom	94%	72h/23	Mortality	2.4 g	2430 (2270-2580)	--------	Singh *et al.* 2004	LL 3,4,7
Colisa fasciatus	Gourami fish	SR	Nom	94%	96h/23	Mortality	2.4 g	2120 (1940-2250)	--------	Singh *et al.* 2004	LL 3,4,7
Crassostrea virginica	Eastern Oyster	FT	Meas	57%	96h/24	Inhibit shell growth	24-37mm	2960 (2040-6970)	96hr 2457	Wade and Wisk 1992	LR 1
Cypria sp	Ostracods/ Crustacean	S	Nom	56%	48h/21	Mortality	NR	2.0 (1.6-2.7)	--------	Naqvi & Hawkins 1989	LL 1,7
Cypridopsis	Crustacean	S	NR	95%	96h/21	Mortality	Mature	47 (32-69)	--------	Johnson & Finley 1980	LL 4,7
Cyprinodon variegatus	Minnow	FT	Meas	94%	96h/22	Mortality	0.033g, 11mm	40 (18-74)	NOEC 96hr 18	Bowman 1989a	LR 5
Cyprinodon variegatus	Minnow	FT	Meas	57%	96h/22	Mortality	0.16g, 17mm	55 (47-64)	NOEC 14	Bowman 1989b	LR 1,5
Cyprinus carpio	Carp	SR	Nom	57%	96h/25	Mortality	Juvenile	11870	--------	Alam & Maugham 1992	LL 1,7
Cyprinus carpio	Carp	SR	Nom	57%	96h/25	Mortality	Adult	11531	--------	Alam & Maugham 1992	LL 1,7
Cyprinus carpio	Carp	S	Nom	50%	96h/24	Mortality	Eggs	12930 (10810-15450)	--------	Kaur & Dhawn 1993	LL 1,7
Cyprinus carpio	Carp	S	Nom	50%	96h/24	Mortality	Larvae: 7d	710 (240-1240)	--------	Kaur & Dhawn 1993	LL 1,7
Cyprinus carpio	Carp	S	Nom	50%	96h/24	Mortality	Fry: 30d	2100 (1220-3610)	--------	Kaur & Dhawn 1993	LL 1,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Cyprinus carpio	Carp	S	NR	95%	96h/18	Mortality	0.6 g	6590 (4920-8820)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Danio rerio	Zebrafish	S	Nom	NR	72h/26	Hatchability	Eggs	165 (161- 169)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	96h/26	Mortality	Eggs	155 (150-160)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	120h/26	Mortality	Eggs	105 (101-108)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	144h/26	Mortality	Eggs	50 (46-53)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	NR	168h/26	Mortality	Eggs	35 (27-44)	--------	Ansari & Kumar 1986	LL 1,7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Mortality	Eggs	--------	2236	Cook et al 2005	RL 7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Length	Eggs	--------	1732	Cook et al 2005	RL 7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Abdominal area	Eggs	--------	2236	Cook et al 2005	LL 2,7
Danio rerio	Zebrafish	S	Nom	99%	120h/28	Hatching	Eggs	--------	No effect	Cook et al 2005	LL 2,7
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Larval mortality	eggs, blastula stage	1800 (1500-2000)	--------	Nguyen & Janssen 2001	LL 4
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Embryo survival	eggs, blastula stage	--------	LOEC = 10,000	Nguyen & Janssen 2001	LL 4,6
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Hatching	eggs, blastula stage	--------	1700	Nguyen & Janssen 2001	LL 4
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Larval survival	eggs, blastula stage	--------	1700	Nguyen & Janssen 2001	LL 4

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (^{o}C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Abnormality	eggs, blastula stage	--------	1700	Nguyen & Janssen 2001	LL 4,2
Danio rerio	Zebrafish	SR	Nom	98%	5d/25	Growth	eggs, blastula stage	--------	LOEC >1000	Nguyen & Janssen 2001	LL 4,6
Daphnia magna	Cladoceran	S	Nom	95%	24h/20	Mortality	4th instar/ juvenile	1.0 (0.7-1.4)	--------	Barata *et al.* 2004	LL 4,7
Daphnia magna	Cladoceran	S	NR	95%	48h/25	Immobility/ Mortality	1st instar	1.0 (0.7-1.4)	--------	Johnson & Finley 1980	LL 4,7
Daphnia magna	Cladoceran	S	NR	99%	48h/20	Immobility/ Mortality	< 24 h	3.6 (3.35-3.89)	--------	Printes & Callaghan 2004	LR 7,8
Daphnia magna	Cladoceran	FT	Meas	57%	48h/19-20	Mortality	neonates <24hr	2.2 (1.9-2.5)	48hr 0.26	Burgess 1989a	LR 1
Daphnia pulex	Cladoceran	S	NR	95%	48h/25	Immobility/ Mortality	1st instar	1.8 (1.4-2.4)	--------	Johnson & Finley 1980	LL 4,7
Diaptomus sp	Copepods/ crustacean	S	Nom	56%	48h/21	Mortality	NR	2.0 (1.8-2.5)	--------	Naqvi & Hawkins 1989	LL 1,7
Eucyclops sp	Copepods/ crustacean	S	Nom	56%	48h/21	Mortality	NR	1.0 (0.8-1.3)	--------	Naqvi & Hawkins 1989	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	24h/14	Mortality	20 mm, 0.5g	0.846 (0.798-0.94)	--------	Khangarot *et al.* 1985	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	48h/14	Mortality	20 mm, 0.5g	0.613 (0.55-0.69)	--------	Khangarot *et al.* 1985	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	72h/14	Mortality	20 mm, 0.5g	0.613 (0.55-0.69)	--------	Khangarot *et al.* 1985	LL 1,7
Euphlyctis hexadactylus	Frog	SR	Nom	50%	96h/14	Mortality	20 mm, 0.5g	0.59 (0.43-0.78)	--------	Khangarot *et al.* 1985	LL 1,7
Gambusia affinis	Mosquito fish	S	Nom	NR	48h/32	Mortality	Adult	1230	--------	Milam *et al.* 2000	LL 1,4,7
Gambusia affinis	Mosquito fish	S	Nom	56.1%	96h/20	Mortality	adult, 0.289g, 2.76 cm	200 (190-250)	--------	Naqvi & Hawkins 1988	LL 1,7
Gammarus	Amphipod	S	NR	95%	96h/21	Mortality	Mature	0.76	--------	Johnson &	LL

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
fasciatus								(0.63-0.92)		Finley 1980	4,7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	24h/21	Mortality	NR	1.2	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	48h/21	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	96h/21	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	IF	Nom	Technical	120h/21	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	24h/21, recons water	Mortality	NR	3.8	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	24h/21, well water	Mortality	NR	3.2	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	48h/21, well water	Mortality	NR	2.0	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	96h/21, well water	Mortality	NR	0.9	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	96h/21, recons water	Mortality	NR	0.8	--------	Sanders 1972	RL 7
Gammarus fasciatus	Amphipod	S	Nom	Technical	120h/21, well water	Mortality	NR	0.5	--------	Sanders 1972	RL 7
Gammarus palustris	Amphipod	S	NR	Technical	96h/20	Mortality	amphipods	4.65 (3.47-6.21)	--------	Leight & Van Dolah 1999	LL 5
Gammarus palustris	Amphipod	SR	NR	Technical	96h/20	Mortality	amphipods	2.29 (1.74-3.03)	--------	Leight & Van Dolah 1999	LL 5
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	24h/18	Mortality	5-10 g	11750	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	24h/18	Mortality	5-10 g	18490	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	48h/18	Mortality	5-10 g	10960	--------	Verma *et al.* 1982	LL 1,7

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Heteropneustes fossilis	Stinging catfish	S	Nom	50%	48h/18	Mortality	5-10 g	17180	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	72h/18	Mortality	5-10 g	10580	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	72h/18	Mortality	5-10 g	16180	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	96h/18	Mortality	5-10 g	9790	--------	Verma *et al.* 1982	LL 1,7
Heteropneustes fossilis	Stinging catfish	S	Nom	50%	96h/18	Mortality	5-10 g	15000	--------	Verma *et al.* 1982	LL 1,7
Hexagenia	Mayfly	S	Nom	95%	24h/24	Mortality	Naiad	631 (429-834)	--------	Carlson 1966	RL 7
Hydropsyche	Caddisfly	S	Nom	95%	24h/24	Mortality	Naiad	12.3 (10.2-15.1)	--------	Carlson 1966	RL 7
Hydropsyche	Caddisfly	S	NR	95%	96h/15	Mortality	Juvenile	5 (2.9-8.6)	--------	Johnson & Finley 1980	LL 4,7
Hyla versicolor	Grey tree frog	SR	Nom	50%	16d/20.1-20.2	Mortality	Tadpole stage 25	2000-4100	--------	Relyea 2004	LL 1,4
Ictalurus melas	Black bullhead	S	NR	95%	96h/18	Mortality	1.2 g	12900 (10700-15600)	--------	Johnson & Finley 1980	LL 4,7
Ictalurus melas	Black bullhead	S	Nom	95%	96h/18	Mortality	0.6-1.7 g	12900 (10700-15600)	--------	Macek & McAllister 1970	LL 4,7
Ictalurus punctatus	Channel catfish	S	NR	95%	96h/18	Mortality	1.5 g	8970 (6780-12000)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Isoperia	Stonefly	S	NR	95%	96h/15	Mortality	Second year class	0.69 (0.20-2.4)	--------	Johnson & Finley 1980	LL 4,7
Labeo rohita	Carp	SR	Nom	50%	96h/24	Mortality	5 g	9.0 µl/L (9.98 - 8.11)	--------	Patil & David 2008	LR 1,4
Lepomis cyanellus	Green sunfish	S	NR	95%	96h/18	Mortality	1.1 g	175 (134-228)	--------	Johnson & Finley 1980	LL 4,7
Lepomis macrochirus	Bluegill sunfish	S	Nom	95%	48h/18.3	Mortality	35-75mm	24hr LC50 - 125	--------	Ludman 1969	LL 7,8

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Lepomis macrochirus	Bluegill	S	Nom	95%	48h/18.3	Mortality	35-75mm	48hr LC50 - 88	--------	Ludman 1969	LL 7,8
Lepomis macrochirus	Bluegill	FT	Meas	95%	96h/NR	Mortality	1.5 g	131	--------	Eaton 1970	LL 4,7
Lepomis macrochirus	Bluegill	FT	Meas	95%	96h/NR	Mortality	1.5 g	89	--------	Eaton 1970	LL 4,7
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	Spawning	1.5 g	--------	--------	Eaton 1970	LL 6
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC52 = 14.6	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC54 = 7.4	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC67 = 3.6	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC65 = 1.6	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	AChE inhibition	1.5 g	--------	IC79 = 0.7	Eaton 1970	LL 2
Lepomis macrochirus	Bluegill	S	Nom	Technical	24h/12.7	Mortality	0.6 – 1.5 g	220 (200-240)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	24h/18.3	Mortality	0.6 – 1.5 g	140 (120-160)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	24h/23.8	Mortality	0.6 – 1.5 g	110 (97-1200)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	96h/12.7	Mortality	0.6 – 1.5 g	120 (67-210)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	96h/18.3	Mortality	0.6 – 1.5 g	55 (51-59)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	Technical	96h/23.8	Mortality	0.6 – 1.5 g	46 (40-52)	--------	Macek et al 1969	LL 4,7
Lepomis macrochirus	Bluegill	S	NR	95%	96h/18	Mortality	1.5 g	103 (87-122)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Lepomis macrochirus	Bluegill	S	Nom	100%	24h/25	Mortality	1.5-2.5 in., 1-2 g,	140	--------	Pickering *et al.* 1962	LL 4,8

Species	**Common identifier**	**Test type**	**Meas/ Nom**	**Chemical grade**	**Duration/ temp (°C)**	**Endpoint**	**Age/ size**	**LC_{50}/ EC_{50} (µg/L)**	**MATC (µg/L)**	**Reference**	**Rating/ Reason**
Lepomis macrochirus	Bluegill	S	Nom	100%	48h/25	Mortality	1.5-2.5 in., 1-2 g,	120	--------	Pickering *et al.* 1962	LL 4,8
Lepomis macrochirus	Bluegill	S	Nom	100%	96h/25	Mortality	1.5-2.5 in., 1-2 g,	90	--------	Pickering *et al.* 1962	LL 4,8
Lepomis macrochirus	Bluegill	FT	Meas	95%	10mo/9-29	Mortality	1.5 g	-------	10.4	Eaton 1970	LL 4,6
Lepomis microlophus	Redear sunfish	S	NR	95%	96h/24	Mortality	3.2 g	62 (58-67)	--------	Johnson & Finley 1980	LL 4,7
Lepomis microlophus	Redear sunfish	S	Nom	95%	96h/18	Mortality	0.6-1.7 g	170 (132-220)	--------	Macek & McAllister 1970	LL 4,7
Lestes	Insect	S	NR	95%	96h/15	Mortality	Juvenile	10 (6.5-15)	--------	Johnson & Finley 1980	LL 4,7
Lestes congener	Insect	S	Nom	94%	96h/25	Mortality	Late instar nymphs	300	--------	Federle & Collins 1976	RL 7
Limnephilius	Insect	S	NR	95%	96h/15	Mortality	Juvenile	1.3 (0.8-2.0)	--------	Johnson & Finley 1980	LL 4,7
Micropterus salmoides	Largemoun t bass	S	NR	95%	96h/18	Mortality	0.9 g	285 (254-320)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Moina macrocopa	Cladoceran	SR	Nom	81%	11d/25	Longevity	< 18 h	--------	LOEC 0.01	Wong *et al.* 1995	LL 6,7
Mysidopsis bahia	Fairy shrimp	S	Nom	94.5%	96h/25	Mortality	≤ 24 h	5.2	--------	Cripe *et al.*1989	LR 5
Mysidopsis bahia	Fairy shrimp	S	Nom	94.5%	96h/25	Mortality	≤ 24 h	5.7	--------	Cripe *et al.*1989	LR 4,5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	5.2 (24h)	---------	Burgess 1989b MRID4118920 1	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	3.7 (48h)	---------	Burgess 1989b	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	2.8 (72h)	---------	Burgess 1989b	LR 5

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	8-9d	2.1 (1.5-2.6) (96h)	NOEC 96hr 0.87	Burgess 1989b	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	9-10d	3.6 (48h)	---------	Forbis 1990	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	9-10d	2.3 (72h)	---------	Forbis 1990	LR 5
Mysidopsis bahia	Fairy shrimp	FT	Meas	94%	96h/21-22	Mortality	9-10d	2.2 (1.5-2.6) (96h)	NOEC 96hr 1.5	Forbis 1990	LR 5
Mysidopsis bahia	Fairy shrimp	S	NR	99.9%	96h/25	Mortality	≤ 24 h	11	--------	Cripe 1994	LR 5
Notonecta undulata	Insect	S	Nom	94%	24h/25	Mortality	Late instar nymphs	220	--------	Federle & Collins 1976	RL 7
Notonecta undulata	Insect	S	Nom	94%	48h/25	Mortality	Late instar nymphs	110	--------	Federle & Collins 1976	RL 7
Notonecta undulata	Insect	S	Nom	94%	72h/25	Mortality	Late instar nymphs	80	--------	Federle & Collins 1976	RL 7
Notonecta undulata	Insect	S	Nom	94%	96h/25	Mortality	Late instar nymphs	80	--------	Federle & Collins 1976	RL 7
Notopterus-notopterus	Knifefish	SR	Nom	Technical	96h/22	Mortality	8.6-11 cm, 14.4-19.0 g	77 (61-103)	--------	Gupta et al 1994	LL 3,7
Oncorhynchus clarki	Cutthroat trout	S	NR	95%	96h/12	Mortality	1.0 g	280 (270-310)	--------	Johnson & Finley 1980	LL 4,7
Oncorhynchus kisutch	Coho salmon	SR	Meas	98%	96h/12	AChE inhibition	1.3 g	74.5	--------	Laetz *et al.* 2009	LR 2
Oncorhynchus kisutch	Coho salmon	S	NR	95%	96h/12	Mortality	0.9 g	170 (160-180)	--------	Johnson & Finley 1980	LL 4,7
Oncorhynchus kisutch	Coho salmon	S	Nom	95%	96h/13	Mortality	0.6-1.7 g	101 (89-115)	--------	Macek & McAllister	LL 4,7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
										1970	
Oncorhynchus mykiss	Rainbow trout	SR	Nom	99.5%	24h/15	AChE inhibition	40 d, 30.8 mm, 0.24 g	--------	LOEC 20	Beauvais *et al.* 2000	LL 2,6,7
Oncorhynchus mykiss	Rainbow trout	SR	Nom	99.5%	96h/15	AChE inhibition	40 d, 30.8 mm, 0.24 g	--------	NOEC 40	Beauvais *et al.* 2000	LL 2,6,7
Oncorhynchus mykiss	Rainbow trout	SR	Nom	99.5%	96h + recov/15	AChE inhibition	40 d, 30.8 mm, 0.24 g	--------	LOEC 20	Beauvais *et al.* 2000	LL 2,6,7
Oncorhynchus mykiss	Rainbow trout	S	NR	95%	96h/12	Mortality	1.4 g	200 (160-240)	--------	Johnson & Finley 1980	LL 4,7
Oncorhynchus mykiss	Rainbow trout	S	Nom	95%	96h/13	Mortality	0.6-1.7 g	170 (160-180)	--------	Macek & McAllister 1970	LL 4,7
Oncorhynchus tshawytscha	Chinook salmon	S	Nom	50%	24h/9	Mortality	3.8 cm	170	--------	Parkhurst & Johnson 1955	LL 1,7
Oncorhynchus tshawytscha	Chinook salmon	S	Nom	50%	48h/9	Mortality	3.8 cm	150	--------	Parkhurst & Johnson 1955	LL 1,7
Oncorhynchus tshawytscha	Chinook salmon	S	Nom	50%	96h/9	Mortality	3.8 cm	120	--------	Parkhurst & Johnson 1955	LL 1,7
Orconectes nais	Crayfish	S	Nom	Technical	24h/21	Mortality	Early instar, 3-5 w old, 30-50mg	290	--------	Sanders 1972	RL 7
Orconectes nais	Crayfish	S	Nom	Technical	96h/21	Mortality	Early instar, 3-5 w old, 30-50mg	180	--------	Sanders 1972	RL 7
Oreochromis niloticus	Nile Tilapia	S	Nom	98%	96h/28	Mortality	5-8g	2200	--------	Pathiratne & George 1998	RL
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	24h/21	Mortality	NR	150	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	48h/21	Mortality	NR	25	--------	Sanders 1972	RL 7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	96h/21	Mortality	NR	15	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	IF	Nom	Technical	120h/21	Mortality	NR	9	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	24h/21	Mortality	NR	320	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	48h/21	Mortality	NR	100.0	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	96h/21	Mortality	NR	90.0	--------	Sanders 1972	RL 7
Palaemonetes kadiakensis	Glass shrimp	S	Nom	Technical	120h/21	Mortality	NR	60.0	--------	Sanders 1972	RL 7
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	1-2d old	9.06 (7.56-10.73)	--------	Key et al 1998	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	18day larvae	13.24 (9.91-17.70)	--------	Key et al 1998	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	adults	38.19 (31.91-45.69)	--------	Key et al 1998	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	1-2d old	8.94 (7.53-10.63)	96hr 2.66	Key and Fulton 2006	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	18day larvae	13.26 (9.67-15.98)	LOEC 96hr 12.5	Key and Fulton 2006	LR 5
Palaemonetes pugio	Glass shrimp	SR	Nom	Technical	96h/25	Mortality	adults	38.19 (31.91-45.69)	96hr 17.68	Key and Fulton 2006	LR 5
Paratya compressa improvisa	Shrimp	S	Nom	98%	96h/22	Mortality	4 wk; 8.27 mm	4	--------	Shigehisa & Shiraishi 1998	LL 4,6,7
Pelophylax ridibundus	Marsh frog	S	Nom	95%	96h/NR	Mortality	21st Gosner stage	38,000 □g/L (35.11-48.25)	--------	Sayim 2008	RL 7
Peltodytes spp.	Crawling water beetles	S	Nom	94%	24h/25	Mortality	Adult; 0.005 g	6800	--------	Federle & Collins 1976	RL 7

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Peltodytes spp.	Crawling water beetles	S	Nom	94%	48h/25	Mortality	Adult; 0.005 g	1500	--------	Federle & Collins 1976	RL 7
Peltodytes spp.	Crawling water beetles	S	Nom	94%	72h/25	Mortality	Adult; 0.005 g	1200	--------	Federle & Collins 1976	RL 7
Peltodytes spp.	Crawling water beetles	S	Nom	94%	96h/25	Mortality	Adult; 0.005 g	1000	--------	Federle & Collins 1976	RL 7
Penaeus duorarum	Pink shrimp	S	NR	99.9%	96h/25	Mortality	3-5d	12	--------	Cripe 1994	LR 5
Perca flavescens	Yellow perch	S	NR	95%	96h/18	Mortality	1.4 g	64 (59-70)	--------	Johnson & Finley 1980	LL 4,7
Perca flavescens	Yellow perch	S	Nom	95%	96h/18	Mortality	0.6-1.7 g	263 (205-338)	--------	Macek & McAllister 1970	LL 4,7
Pimephales promelas	Fathead minnow	FT	Meas	95%	96h/25	Loss of equilibrium, spinal deformity, hemorrhaging	29-30 d; 0.069 g; 1.7 cm	EC50: 10,600	--------	Geiger *et al.* 1984	LR 2
Pimephales promelas	Fathead minnow	S	Meas	95%	96h/18	Mortality	0.9 g	8650 (6450-11,500)	--------	Macek & McAllister 1970; Johnson & Finley 1980	LL 4,7
Pimephales promelas	Fathead minnow	FT	Meas	95%	10mo/15-26	Mortality	2.5 cm	--------	341	Mount & Stephan 1967	LR 6
Pimephales promelas	Fathead minnow	FT	Meas	95%	10mo/15-26	Spawining	2.5 cm	--------	NR	Mount & Stephan 1967	LR 6
Pimephales promelas	Fathead minnow	S	Nom	100%	24h/25	Mortality (softwater)	1.5-2.5 in., 1-2 g	26,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	24h/25	Mortality (hardwater)	1.5-2.5 in., 1-2 g	23,000	--------	Pickering *et al.* 1962	LL 4,8

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Pimephales promelas	Fathead minnow	S	Nom	100%	48h/25	Mortality (softwater)	1.5-2.5 in., 1-2 g	24,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	48h/25	Mortality (hardwater)	1.5-2.5 in., 1-2 g	18,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	96h/25	Mortality (softwater)	1.5-2.5 in., 1-2 g	23,000	--------	Pickering *et al.* 1962	LL 4,8
Pimephales promelas	Fathead minnow	S	Nom	100%	96h/25	Mortality (hardwater)	1.5-2.5 in., 1-2 g	16,000	--------	Pickering *et al.* 1962	LL 4,8
Poecilia reticulata	Guppy	S	Nom	100%	24h/25	Mortality	0.75-1 in., 0.1-0.2 g	930	--------	Pickering *et al.* 1962	LL 4,8
Poecilia reticulata	Guppy	S	Nom	100%	24h/25	Mortality	0.75-1 in., 0.1-0.2 g	880	--------	Pickering *et al.* 1962	LL 4,8
Poecilia reticulata	Guppy	S	Nom	100%	96h/25	Mortality	0.75-1 in., 0.1-0.2 g	840	--------	Pickering *et al.* 1962	LL 4,8
Procambarus clarkii	Crayfish	S	Nom	NR	96h/19	Mortality	15-38 g	No adverse effects	--------	Andreu-Moliner *et al.* 1986	LL 1,6,7
Pteronarcella badia	Stonefly	S	Nom	Technical	96h/15.5	Mortality	20-25mm	24hr LC50 - 10 (6.7-15)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcella badia	Stonefly	S	Nom	Technical	96h/15.5	Mortality	20-25mm	48hr LC50 - 6 (4.1-8.7)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcella badia	Stonefly	S	Nom	Technical	96h/15.5	Mortality	20-25mm	96hr LC50 - 1.1 (0.78-1.5)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcella sp.	Insect	S	NR	95%	96h/15	Mortality	Naiad	1.1 (0.8-1.5)	--------	Johnson & Finley 1980	LL 4,7
Pteronarcys californica	Stonefly	FT	Nom	95%	30d/12.8	Mortality	Naiads	--------	4.5	Jensen & Gaufin 1964b	LR 6
Pteronarcys californica	Stonefly	S	Nom	Technical	96h/15.5	Mortality	30-35mm	24hr LC50 - 35 (23-54)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcys californica	Stonefly	S	Nom	Technical	96h/15.5	Mortality	30-35mm	48hr LC50 - 20 (15-27)	--------	Sanders and Cope 1968	LL 4,9
Pteronarcys californica	Stonefly	S	Nom	Technical	96h/15.5	Mortality	30-35mm	96hr LC50 - 10 (7-13)	--------	Sanders and Cope 1968	LL 4,9

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Pteronarcys sp.	Insect	S	NR	95%	96h/15	Mortality	Second year class	10 (7.0-13)	--------	Johnson & Finley 1980	LL 4,7
Rana catesbeiana	Bullfrog	SR	Nom	50%	16d/21.2-21.5	Mortality	tadpole (stage 25)	1500	--------	Relyea 2004	LL 1,4
Rana catesbeiana	Bullfrog	SR	Nom	96.0%	28d/22-25	Loss of equilibrium	Tadpoles (stage 26)	----------	LOEC 500	Fordham et al 2001	LL 6
Rana clamitans	Green frog	SR	Nom	50%	16d/21.2-21.4	Mortality	tadpole (stage 25)	3700	--------	Relyea 2004	LL 1,4
Rana pipiens	Leopard frog	SR	Nom	50%	16d/18.6-18.7	Mortality	tadpole (stage 25)	2400	--------	Relyea 2004	LL 1,4
Rana sylvatica	Wood frog	SR	Nom	50%	16d/18.7-19	Mortality	tadpole (stage 25)	1300	--------	Relyea 2004	LL 1,4
Salmo gairdnerii	Rainbow trout	S	Nom	95%	96h/12.7	Mortality	63.7mm, 2.28g	24hr LC50 - 59	--------	Ludman 1969	LL 7,8
Salmo gairdnerii	Rainbow trout	S	Nom	95%	96h/12.7	Mortality	63.7mm, 2.28g	48hr LC50 - 42	--------	Ludman 1969	LL 7,8
Salmo gairdnerii	Rainbow trout	S	Nom	95%	96h/12.7	Mortality	63.7mm, 2.28g	96hr LC50 - 34	--------	Ludman 1969	LL 7,8
Salmo trutta	Brown trout	S	NR	95%	96h/12	Mortality	1.1 g	101 (84-115)	--------	Johnson & Finley 1980	LL 4,7
Salmo trutta	Brown trout	S	Nom	95%	96h/13	Mortality	0.6-1.7 g	200 (160-240)	--------	Macek & McAllister 1970	LL 4,7
Salvelinus namaycush	Lake trout	S	NR	95%	96h/12	Mortality	0.3 g	76 (47-123)	--------	Johnson & Finley 1980	LL 4,7
Simocephalus spp.	Cladoceran	S	NR	95%	48h/15	Immobility/ Mortality	1st instar	3.5 (2.6-4.8)	--------	Johnson & Finley 1980	LL 4,7
Simocephalus vetulus	Cladoceran	S	Nom	Technical	48h/23.5	Mortality	≤ 24 h	2.9 (2.4-3.6)	--------	Olvera-Hernandez *et al.* 2004	LL 4,7
Tigriopus brevicornis	Copepod	S	NR	99.9%	96h/20	Mortality	Nauplii	7.2 (5.2-9.2)	--------	Forget et al 1998	LL 4,5
Tigriopus brevicornis	Copepod	S	NR	99.9%	96h/20	Mortality	Copepodid	20.5 (18.5-22.5)	--------	Forget et al 1998	LL 4,5

Species	Common identifier	Test type	Meas/ Nom	Chemical grade	Duration/ temp (°C)	Endpoint	Age/ size	LC_{50}/ EC_{50} (µg/L)	MATC (µg/L)	Reference	Rating/ Reason
Tigriopus brevicornis	Copepod	S	NR	99.9%	96h/20	Mortality	Ovigerous female	24.3 (22.3-26.3)	--------	Forget et al 1998	LL 4,5
Wyeomyia smithii	Mosquito	S	Nom	> 92%	96h/27	Mortality	2nd instar	50-100	--------	Strickman 1985	LL 6,7
Xenopus laevis	African clawed frog	S	Nom	90%	96h/23	Mortality	Tadpole	10,900 (10,600-11,300)	--------	Snawder & Chambers 1989	LL 4,7
Xenopus laevis	African clawed frog	S	Nom	90%	96h/23	Notochordal defect	Eggs	2,160 (2030-2310)	--------	Snawder & Chambers 1989	LL 4,7
Xenopus laevis	African clawed frog	S	Nom	90%	96h/23	Length	Eggs	--------	LOEC: 100 ug/L	Snawder & Chambers 1989	LL 6,7
Xenopus laevis	African clawed frog	S	Nom	95%	96h/23	Notochord Index	Eggs	--------	LOEC: 990 ug/L	Snawder & Chambers 1993	LL 2,6,7

NR = Not reported, S = Static, SR = Static renewal, FT = Flow-through

1. Chemical grade
2. Endpoint not linked to population effects
3. Family not in N. America
4. Control response
5. Not freshwater
6. No toxicity value calculated
7. Low reliability score
8. Control not described
9. No standard

Table 9. Known LC_{50} values for threatened or endangered species.

Species	Common Name	Family	LC50 (µg/L)	Surrogate
		Lab determined values for endangered species		
Oncorhynchus mykiss	Rainbow trout	Salmonidae	122	experimental value
Oncorhynchus kisutch	Coho salmon	Salmonidae	130	experimental value
Oncorhynchus clarki	Cutthroat trout	Salmonidae	150	experimental value
Gila elegans	Bonytail	Cyprinidae	15300	experimental value
Ptychocheilus lucius	Colorado squawfish	Cyprinidae	9140	experimental value

Table 10. Acceptable multispecies field, semi-field, laboratory, microcosm, and mesocosm studies; R = reliable; L = less reliable.

Reference	Habitat	Rating
Relyea 2005	Laboratory microcosm	L
Kennedy and Walsh 1970	Outdoor pond	R

Appendix

Data summary sheets for data rated relevant and reliable

Abbreviations used in this appendix:

NR = Not Reported
RR = Relevant, Reliable study

Unused lines deleted from tables

Summary sheets are in alphabetical order according to species

Toxicity Data Summary

Acroneuria pacifica

Study: Jensen LD, Gaufin AR. 1964a. Effects of Ten Organic Insecticides on Two Species of Stonefly Naiads. Trans. Am. Fish. Soc. 93:27-34.

Relevance
Score: 92.5 (Control response NR)
Rating: R

Reliability
Score: 74
Rating: R

Reference	**Jensen & Gaufin 1964a**	***A. pacifica***
Parameter	**Value**	**Comment**
Test method cited	APHA	
Phylum	Arthropoda	
Class	Insecta	
Order	Plecoptera	
Family	Perlidae	
Genus	*Acroneuria*	
Species	*pacifica*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Naiads, 2-2.5 cm	
Source of organisms	Collected from field, same as dilution water source	
Have organisms been exposed to contaminants?	Possibly	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes 48, 72, 96 h	
Effect 1	Mortality	
Control response 1	NR	
Temperature	11-12°C	
Test type	Static	
Photoperiod/light intensity	NR	
Dilution water	Mill creek, near Salt lake City Utah	
pH	7.9-8.3	
Hardness	122-210 mg/L	
Alkalinity	150 -220 m/L	
Conductivity	NR	
Dissolved Oxygen	7.4-13.5 (initial)	NR during test, but they describe

Reference	**Jensen & Gaufin 1964a**	***A. pacifica***
Parameter	**Value**	**Comment**
		bubbling in compressed air to maintain DO-acceptable
Feeding	None	
Purity of test substance	95%	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone and emulsifier, up to 56 mg/L (0.056 mL/L, if density 1 g/mL)	
Concentration 1 Nom/Meas (µg/L)	5 concentrations, 1-10 ug/L	2 Reps and 10 per
Control	Yes, states species unaffected by solvent & emulsifier so used solvent control (?)	
LC50	(Listed below)	Graphical interpolation
48 h	12.0 ug/L	
72 h	16.0 ug/L	
96 h	7.0 ug/L	

Other notes:
Also reports effects on activity, loss of equilibrium, tremors and convulsions, and death, but only at one concentration (18 ug/L).

Reliability points taken off for:
<u>Documentation:</u> Analytical method (4), Measured concentrations (3), Dissolved oxygen (4), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
<u>Acceptability:</u> Control response (9), Measured conc w/in 20% nominal (4), Prior contamination (4), Organisms randomized (1), Dilution water (2), Conductivity (1), Photoperiod (2), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Acroneuria pacifica

Study: Jensen LD, Gaufin AR. 1964b. Long-Term Effects of Organic Insecticides on Two Species of Stonefly Naiads. Trans. Am. Fish. Soc. 93:357-363.

Relevance; 4d (96h) LC50	Reliability
Score: 90 (no std method)	Score: 77
Rating: R	Rating: R

Relevance; 5d-30d LC50- Value not appropriate for chronic distribution	Reliability
Score: 90 (no std method)	Score: 77
Rating: R	Rating: R

Relevance; 30d NOEC/LOEC	Reliability
Score: 75 (no std method, No values)	Score: 73.5
Rating: L	Rating: R

NOEC LOEC aren't calculated but can be estimated from graph. Only LC50 are calculated and reported as tox values.

Reference	**Jensen & Gaufin 1964b**	***A. pacifica***
Parameter	**Value**	**Comment**
Test method cited	APHA	More just for data analysis
Phylum	Arthropoda	
Class	Insecta	
Order	Amphipoda	
Family	Pteronarcyidae	
Genus	*Acroneuria*	
Species	*pacifica*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Naiad	
Source of organisms	Collected from field, same as dilution water source	Reported in Jensen & Gaufin 1964a
Have organisms been exposed to contaminants?	Possibly, because they were collected from the field	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	30 d	
Data for multiple times?	Yes: 4,5,10,15,20,25,30 d	
Effect 1	Mortality	
Control response 1	No effect *	
Temperature	12.8 ± 0.6°C	

Reference	Jensen & Gaufin 1964b	*A. pacifica*
Parameter	**Value**	**Comment**
Test type	Flow though	
Photoperiod/light intensity	NR	
Dilution water	Mill creek, near Salt lake City Utah	Reported in Jensen & Gaufin 1964a
pH	7.8-8.2	
Hardness	NR	
Alkalinity	165-225 m/L	
Conductivity	NR	
Dissolved Oxygen	9-11 mg/L	
Feeding	None	
Purity of test substance	95%	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	50 mg/L	
Concentration 1 Nom/Meas (μg/L)	8 concentrations, values NR	25 per rep
Control	Yes *	25 per rep
LC_{50} 4 day	7.7 μg/L	
LC_{50} 5-d	7.70 μg/L	
LC_{50} 10-d	5.10 μg/L	
LC_{50} 15-d	3.30 μg/L	
LC_{50} 20-d	3.20 μg/L	
LC_{50} 25-d	2.40 μg/L	
LC_{50} 30-d	0.78 μg/L ***	
NOEC	0.5 μg/L **	Method: no stats p: none MSD: none
LOEC	1 μg/L **	Method: no stats p: none MSD: none
MATC (GeoMean NOEC,LOEC)	0.71 μg/L **	
% control at NOEC	NR	
% of control LOEC	NR	

*States: exposure of both species to acetone and water for 30-d periods within a range of concentration of 5.0 to 50.0 ppm of acetone had no noticeable affect on either species.
**Values estimated from graph, not statically determined
***5-30d LC_{50}- Value is calculated, but not appropriate for chronic distribution or ACR

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentrations (3), Hardness (2), Conductivity (2), Photoperiod (3), Hypothesis tests (6)

Acceptability: Appropriate duration (2), Appropriate control (6), Control response (9), Measured conc w/in 20% nominal (4), Prior contamination (4), Organisms randomized (1), Dilution water (2), Hardness (2), Conductivity (1), Photoperiod (2), Random design (2), Dilution factor (2), Minimum significant difference (1)

Toxicity Data Summary

Anisops sardeus

Study: Lahr J, Badji A, Marquenie S, Schuiling E, Ndour KB, Diallo AO, Everts JW. 2001. Acute Toxicity of Locust Insecticides to Two Indigenous Invertebrates from Sahelian Temporary Ponds. Ecotoxicol. Environ. Saf. 48:66-75.

Relevance
Score: 100
Rating: R

Reliability
Score: 75.5
Rating: R

Reference	**Lahr *et al.* 2001**	***A. sardeus***
Parameter	**Value**	**Comment**
Test method cited	ASTM	
Phylum	Arthropoda	
Class	Insecta	
Order	Hemiptera	
Family	Notonectidae	
Genus	*Anisops*	
Species	*sardeus*	
Family in North America?	Yes, more in Europe	
Age/size at start of test/growth phase	Adult females	
Source of organisms	Nearby ponds	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	Not properly, only 2 h	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24,48 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	< 10%	
Temperature	ca. 27 °C	Monitored During test
Test type	Static	
Photoperiod/light intensity	Ambient 13:11 light:dark	
Dilution water	Well water	
pH	6.9 ± 0.5	
Hardness	Ca & Mg: 32.5 & 9.1 mg/L as CaCO3	
Alkalinity	NR	
Conductivity	300uS/cm	
Dissolved Oxygen	Dropped to 36% at 48 h	Monitored during

Reference	Lahr *et al.* 2001	*A. sardeus*
Parameter	**Value**	**Comment**
		test
Feeding	None	
Purity of test substance	Formulation with high percent AI-1230 g/L AI**	>99%
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone max 0.5 mL/L	
Concentration 1 Nom (μg/L)	5-10 concentrations, logarithmically spaced	1 rep with 10 per (but tests repeated 3x, w varying concentrations)
Control	solvent	2 reps with 10 per
LC_{50}, 24 h	70.7 (57.4-78.0) μg/L ***	parametric method of Kooijman (1981)
LC_{50}, 48 h	42.2 (40.5-44.9) μg/L ***	Same as above

Other notes:
** density of malathion is 1.23 g/mL so this is apparently nearly 100% malathion

***LC_{50} geomean of 3 tests

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Alkalinity (2), Hypothesis tests (8)
Acceptability: Measured conc w/in 20% of nominal (4), Appropriate size (3), Prior contamination (4), Organisms randomized (1), Proper acclimation (1), Alkalinity (2), Dissolved oxygen (6), Temperature > +/- 1°C (3), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Ceriodaphnia dubia

Study: Maul JD, Farris JL, Lydy MJ. 2006. Interaction of chemical cues from fish tissues and organophosphorous pesticides on Ceriodaphnia dubia survival. Environmental Pollution 141:90-97.

Relevance
Score: 100
Rating: R

Reliability
Score: 74
Rating: R

Reference	**Maul *et al.* 2006**	***C. dubia***
Parameter	**Value**	**Comment**
Test method cited	EPA	
Phylum	Arthropoda/Crustacea	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Ceriodaphnia*	
Species	*dubia*	
Family in North America?	Yes	
Age/size at start of test/growth phase	≤ 24 h	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	> 90% survival	
Temperature	25 ± 1 °C	
Test type	Static	
Photoperiod/light intensity	16L:8D	
Dilution water	Synthetic moderately hard	
pH	NR, but monitored	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	> 4mg/L, 50%	recommend by EPA 2002
Feeding	Yes	

Reference	Maul *et al.* 2006	*C. dubia*
Parameter	**Value**	**Comment**
Purity of test substance	99.2 %	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	< 0.3mL/L	
Concentration 1 Nom (µg/L)	20.66	1? reps and 5 per
Concentration 2 Nom (µg/L)	12.40	1? reps and 5 per
Concentration 3 Nom (µg/L)	7.44	1? reps and 5 per
Concentration 4 Nom (µg/L)	4.46	1? reps and 5 per
Concentration 5 Nom (µg/L)	2.68	1? reps and 5 per
Control	Control and solvent control	1? reps and 5 per
LC_{50} (95% CI)	3.35 µg/L (2.68 - 3.93)	Probit

Other notes:
A significant chemical cue (homogenized Pimephales promelas) and malathion interaction was observed on C. dubia survival (P = 0.006). Chemical cue and 2.82 mg/L malathion resulted in a 76.0% reduction in survival compared to malathion alone (P < 0.01).

Reliability points taken off for:
<u>Documentation:</u> Analytical method (4), Measured concentrations (3), Hardness (2), Alkalinity (2), Conductivity (2), pH (3), Hypothesis tests (8)
<u>Acceptability:</u> Measured conc w/in 20% of nominal (4), Organisms randomized (1), Appropriate feeding (3), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Adequate replication (2), Hypothesis tests (3)

Toxicity Data Summary

Ceriodaphnia dubia

Study: Nelson SM, Roline RA. 1998. Evaluation of the Sensitivity of Rapid Toxicity Tests Relative to Daphnid Acute Lethality Tests. Bull. Environ. Contam. Toxicol. 60:292-299.

Which is nearly identical to:

Study: Nelson SM, Roline RA. 1997. Comparison of Rapid Toxicity Tests with a Standard Acute Test. Report BR-EE010, Technical Service Center, Bureau of Reclamation, Denver, CO.12 p. (NTIS #PB97-158919)

Relevance
Score: 100
Rating: R

Reliability
Score: 84
Rating: R

Reference	**Nelson & Roline 1998**	***C. dubia***
Parameter	**Value**	**Comment**
Test method cited	EPA	
Phylum	Arthropoda/Crustacea	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Ceriodaphnia*	
Species	*dubia*	
Family in North America?	Yes	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	Commercial supplier*	Aquatic Bio Systems*
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	24, 48 h	
Effect 1	Mortality	
Control response 1	No mortality*	
Temperature	25 °C	
Test type	Static renewal (24 h)*	
Photoperiod/light intensity	18L:6D	
Dilution water	Moderately hard reconstituted water	

Reference	**Nelson & Roline 1998**	***C. dubia***
Parameter	**Value**	**Comment**
pH	7.30-8.31	
Hardness	8.05-8.54 mg/L	
Alkalinity	NR	
Conductivity	264-457 µS/cm	
Dissolved Oxygen	5.8-10.0 mg/L	8.2 sat at 25= 70%
Feeding	Yes	
Purity of test substance	97%*	
Concentrations measured?	Yes in stock solution, but these concentrations are NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	States solvent not used	
Concentration 1 Nom (µg/L)	6*	4 reps with 5 per
Concentration 2 Nom (µg/L)	3*	4 reps with 5 per
Concentration 3 Nom (µg/L)	1.5*	4 reps with 5 per
Concentration 4 Nom (µg/L)	0.75*	4 reps with 5 per
Concentration 5 Nom (µg/L)	0.375*	4 reps with 5 per
Control	Yes*	4 reps with 5 per
LC_{50}, 24 h (95% CI)	3.18 (2.36-4.27)	trimmed Spearman-Karber
LC_{50}, 48 h (95% CI)	1.14 (1.04-1.25)	trimmed Spearman-Karber

Other notes: Only summarized 24 h & 48 h standard tests here. The results of the other non-standard, faster tests compare very poorly (the authors confirm this), so they are not useful for criteria.

*Author communication used for this information
Emailed Author for missing info on June 2, 2009: SNelson@usbr.gov

Reliability points taken off for:
Documentation: Measured concentrations (3), Alkalinity (2), Hypothesis tests (8)
Acceptability: Measured w/in 20% of nominal (4), Organisms randomized (1), Appropriate feeding (3), Proper acclimation (1), Alkalinity (2), Temperature > +/- 1°C (3), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Chironomus dilutus (tentans)

Study: Belden JB, Lydy MJ. 2000. Impact of atrazine on organophosphate insecticide toxicity. Environ. Toxicol. Chem. 19: 2266-2274.

Relevance	Reliability
Score: 92.5 (Control response NR)	Score: 79
Rating: R	Rating: R

Reference	**Belden & Lydy 2000**	***C. dilutus (tentans)***
Parameter	**Value**	**Comment**
Test method cited	USEPA 1994	See full reference below
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Chironomidae	
Genus	*Chironomus*	
Species	*tentans*	
Found in	North America	
Age/size at start of test	4^{th} instar; 0.63-0.71 mm wide; $\geq$ 1.0 cm long	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	No	
Effect 1	Immobility + Mortality	
Control response 1	NR	
Temperature	20 $\pm$ 1^{o}C	
Test type	Static	
Photoperiod	16L:8D	
Dilution water	MHSFW	
pH	7.3-7.8	
Hardness	NR	
Alkalinity	NR	
Conductivity	320-350 uS/cm	
Dissolved Oxygen	> 70%	
Feeding	NR	

Reference	Belden & Lydy 2000	*C. dilutus (tentans)*
Parameter	**Value**	**Comment**
Purity of test substance	> 98%	
Concentrations measured?	Yes	Nominal values used in calcs since measured values were w/in 10% (likely w/in error of extraction and analysis procedure)
Measured is what % of nominal?	> 90%	
Chemical method documented?	Yes	
Concentration of carrier (if any) in test solutions	50 µL/L acetone	
Concentration 1 Nom/Meas (µg/L)	NR; post-test values were 76-85% of initial values	Reps: 3 w/10 per
Concentration 2 Nom/Meas (µg/L)	NR; post-test values were 76-85% of initial values	Reps: 3 w/10 per
Concentration 3 Nom/Meas (µg/L)	NR; post-test values were 76-85% of initial values	Reps: 3 w/10 per
Concentration 4 Nom/Meas (µg/L)	NR; post-test values were 76-85% of initial values	Reps: 3 w/10 per
Concentration 5 Nom/Meas (µg/L)	NR; post-test values were 76-85% of initial values	Reps: 3 w/10 per
Control	Dilution water; solvent	Reps: 3 w/10 per
ECx (95% ci); ug/L	EC_1: 0.26 (0.13–0.40) EC_5: 0.44 (0.26–0.61) EC_{15}: 0.70 (0.48–0.90) EC_{50}: 1.5 (1.2–1.9)	probit

Other notes:
Study showed no synergism between malathion and atrazine. Only data for malathion alone is shown here for use in criteria derivation, but synergism data is useful for consideration of mixtures.

USEPA. 1994. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminant with freshwater invertebrates. EPA/600/R-94/024. US Environmental Protection Agency, Washington, DC.

Reliability points taken off for:
<u>Documentation:</u> Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Minimum significant difference (2), % control at NOEC/LOEC (2)
<u>Acceptability:</u> Control response (9), Organisms randomized (1), Hardness (2), Alkalinity (2), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Chironomus tentans

Study: Pape-Lindstrom PA, Lydy MJ. 1997. Synergistic toxicity of atrazine and organophosphate insecticides contravenes the response addition mixture model. Environmental Toxicology and Chemistry 16:2415-2420.

Relevance
Score: 90 (No std method)
Rating: R

Reliability
Score: 78
Rating: R

Reference	**Pape-Lindstrom & Lydy 1997**	***C. tentans***
Parameter	**Value**	**Comment**
Test method cited	EPA, but for water and culture only really	
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Chironomidae	
Genus	*Chironomus*	
Species	*tentans*	midge
Family in North America?	Yes	
Age/size at start of test/growth phase	4th instar	
Source of organisms	Lab culture, from EPA stock	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	No	
Effect 1	Immobility/mortality	
Control response 1	< 5%	
Temperature	20 ± 1 °C	
Test type	Static	
Photoperiod/light intensity	16:8 Light:dark	
Dilution water	EPA moderately hard water	
pH	7.95 (SD = 0.19)	
Hardness	NR	
Alkalinity	NR	
Conductivity	361 (SD = 10.3)	
Dissolved Oxygen	88.8 % (SD = 7.1)	
Feeding	None	

Reference	Pape-Lindstrom & Lydy 1997	*C. tentans*
Parameter	**Value**	**Comment**
Purity of test substance	99 %	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	0.5 mL/L acetone	
Concentrations Nom (μg/L)	5 concentrations	3 Reps -10 per rep
Control	Solvent and water only	3 Reps -10 per rep
EC_{50}	19.09 (11.98-30.44) μg/L	Probit method

Other notes:

Greater than additive effects with atrazine

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Hypothesis tests (8)
Acceptability: Standard method (5), Measured conc w/in 20% of nominal (4), Appropriate size (3), Organisms randomized (1), Hardness (2), Alkalinity (2), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Clarias gariepinus

Study: Lien NTH, Adriaens D, Janssen CR. 1997. Morphological Abnormalities in African Catfish (Clarias gariepinus) Larvae Exposed to Malathion. Chemosphere 35:1475-1486.

Relevance: mortality, length
Score: 90 (no std method)
Rating: R

Reliability
Score: 73.5
Rating: R

Relevance: abnormality, yolk sac edema, notochord deformity
Score: 75 (Endpoint, No std method)
Rating: L

Reference	**Lien *et al.* 1997**	***C. gariepinus***
Parameter	**Value**	**Comment**
Test method cited	None	
Phylum	Chordata	
Class	Actinopterygii	
Order	Siluriformes	
Family	Clariidae	
Genus	*Clarias*	
Species	*gariepinus*	Airbreathing catfish
Family in North America?	Yes, invasive in Florida	Native to Africa/Asia
Age/size at start of test/growth phase	3-5 h post hatch	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	5 d	
Data for multiple times?	No	
Effect 1	Mortality (%)	
Control response 1	2.1 ± 4.2 %	
Effect 2	Abnormalities (%)	No link to survival growth or repro.
Control response 2	6.5 ± 8.1 %	
Effect 3	Body length (mm)	
Control response 3	7.82 ± 0.49 mm	
Effect 4	Abnormal notochord	No link to survival growth or repro.
Control response 4	0 %	

Reference	**Lien *et al.* 1997**	***C. gariepinus***
Parameter	**Value**	**Comment**
Effect 5	Yolk sac edema	No link to survival growth or repro.
Control response 5	About 7%	
Effect 6	Other abnormality	No link to survival growth or repro.
Control response 6	0%	
Temperature	27 ± 1°C	
Test type	Static with daily renewal	
Photoperiod/light intensity	Darkness	
Dilution water	'standard dilution water'	Actual source not clear
pH	7.6 ± 0.2	
Hardness	200 mg/L	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	8.0 ± 0.1 mg/L	
Feeding	None	
Purity of test substance	98 %	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	0.5 mL/L acetone	
Concentration 1 Nom (µg/L)	300	1 rep with 4 per*
Concentration 2 Nom (µg/L)	630	1 rep with 4 per
Concentration 3 Nom (µg/L)	1250	1 rep with 4 per
Concentration 4 Nom (µg/L)	2500	1 rep with 4 per
Concentration 5 Nom (µg/L)	5000	1 rep with 4 per
Control	Yes, probably water only. States elsewhere that solvent had no effect in a separate test.	1 rep with 4 per
LC50	NR	
Mortality		
NOEC	2500 µg/L	Method: ANOVA w Duncan's test p: 0.05, MSD: NR
LOEC	5000 µg/L	
MATC (GeoMean NOEC,LOEC)	3536 µg/L	
% control at NOEC	429 %	
% of control LOEC	1342 %	
Abnormality		
NOEC	1250 µg/L	Method: ANOVA w Duncan's test p: 0.05, MSD: NR
LOEC	2500 µg/L	

Reference	Lien *et al.* 1997	*C. gariepinus*
Parameter	**Value**	**Comment**
MATC (GeoMean NOEC,LOEC)	1768 µg/L	
% control at NOEC	257 %	
% of control LOEC	666 %	
Body length		
NOEC	1250 µg/L	Method: ANOVA w Duncan's test p: 0.05, MSD: NR
LOEC	2500 µg/L	
MATC (GeoMean NOEC,LOEC)	1768 µg/L	
% control at NOEC	94 %	
% of control LOEC	86 %	
Notochord		
NOEC	1250 µg/L	Method: ANOVA w Duncan's test p: 0.05, MSD: NR
LOEC	2500 µg/L	
MATC (GeoMean NOEC,LOEC)	1768 µg/L	
% control at NOEC	About 8/0 *100% Alternatively 92/100 = 92%	Control response was 0%, so converted negative response 100 %
% of control LOEC	About 40/0 *100% Alternatively 60/100 = 60%	
Yolk sac edema		
NOEC	2500 µg/L	Method: ANOVA w Duncan's test p: 0.05, MSD: NR
LOEC	5000 µg/L	
MATC (GeoMean NOEC,LOEC)	3536 µg/L	
% control at NOEC	About 171%	
% of control LOEC	About 457 %	

Other notes:

- In table 1 states n ≥ 4
- 5 day larval test- Not clear if this is really chronic data. Can't be acute since no LC50. 5 d is short for chronic test, but newly hatched larvae are often the most sensitive life stage of fish.
- The second endpoint of abnormality was later divided into specific abnormalities of notochord abnormality, yolk sac edema and other abnormalities.

Reliability points taken off for:
<u>Documentation:</u> Analytical method (4), measured concentrations (3), Dilution water source (3), Alkalinity (2), Conductivity (2), Minimum significant difference (2), Point estimates (8)
<u>Acceptability:</u> Standard method (5), Appropriate control (6), Measured conc w/in 20% of nominal (4), Organisms randomized (1), Adequate number per rep (2), Hardness (2), Alkalinity (2), Conductivity (1), Random design (2), Minimum significant difference (1), Point estimates (3)

Toxicity Data Summary

Clarias gariepinus

Study: Nguyen LTH, Janssen CR. 2002. Embryo-Larval Toxicity Tests with the African Catfish (Clarias gariepinus): Comparative Sensitivity of Endpoints. Arch. Environ. Contam. Toxicol. 42:256-262.

Relevance
Score: 90 (No std method)
Rating: R

Reliability
Score: 74.5
Rating: R

Reference	**Nguyen & Janssen 2002**	***C. gariepinus***
Parameter	**Value**	**Comment**
Test method cited	None	
Phylum	Chordata	
Class	Actinopterygii	
Order	Siluriformes	
Family	Clariidae	
Genus	*Clarias*	
Species	*gariepinus*	Airbreathing catfish
Family in North America?	Yes, invasive in Florida	Native to Africa/Asia
Age/size at start of test/growth phase	Eggs (immediately after fertilization)	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	5 d	
Data for multiple times?	No	
Effect 1	Larvae survival	
Control response 1	86%	
Effect 2	Larvae length	
Control response 2	7.39 mm	
Effect 3	Larvae weight	
Control response 3	0.33 mg	
Temperature	27 ± 1°C	
Test type	Static renewal (every 24 h)	
Photoperiod/light intensity	Dark	
Dilution water	Dechlorinated tap	
pH	7.7 ± 0.2	
Hardness	200 mg/L as $CaCO_3$	

Reference	Nguyen & Janssen 2002	*C. gariepinus*
Parameter	**Value**	**Comment**
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	7. 3 ± 0.1 mg/L	
Feeding	None	
Purity of test substance	98 %	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	0.1% acetone, about 1 mL/L	
Concentration 1 Nom/Meas (µg/L)	5 concentrations, levels NR	4 reps with 24 per
Control	Water only, but states max solvent concentration tested and no harmful effects	4 reps with 24 per
NOEC	Larval survival: 1250 µg/L Length : 630 µg/L Width: 630 µg/L	Method: ANOVA p: ≤ 0.05 MSD: NR
LOEC	Larval survival: 2500 µg/L Length: 1250 µg/L Width: 1250 µg/L	
MATC (GeoMean NOEC,LOEC)	Larval survival: 1768 µg/L Length: 887 µg/L Width: 887 µg/L	
% control at NOEC	Larval survival: 106% Length: 94% Width: 100%	
% of control LOEC	Larval survival: 69 % Length: 94% Width: 70%	

Other notes: Endpoint: NOEC/ LOEC is chronic, but test only 5 d. Documents chronic/sublethal effects in length weight. Survival can be chronic too but usually long term. Chronic usually partial life, though this covers transitions from egg to larvae.

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Alkalinity (2), Conductivity (2), Minimum significant difference (2), Point estimates (8)
Acceptability: Standard method (5), Test duration (2), Measured conc w/in 20% of nominal (4), Carrier solvent (4), Organisms randomized (1), Alkalinity (2), Conductivity (1), Random design (2), Dilution factor (2), Minimum significant difference (1), Point estimates (3)

Toxicity Data Summary

Daphnia magna

Blakemore G, Burgess D. 1990. Chronic toxicity of Cythion to Daphnia magna under flow-through test conditions. In *Malathion registration standard*, Analytical Bio-Chemistry laboratories, Inc.: Columbia, MO. pp 21-22. MRID 41718401.

Relevance	Reliability
Score: 100	Score: 97.5
Rating: R	Rating: R

Reference	**Blakemore & Burgess 1990**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	EPA-660/3-75-009 ASTM E-35.21	
Phylum	Arthropoda	
Class	Branchiopoda	
Order	Diplostraca	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Family in North America?	Yes	
Age/size at start of test/growth phase	First instar (<24hr)	
Source of organisms	ABC labs in house culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	21 days	
Data for multiple times?	0, 4, 7, 14, 21	
Effect 1	Mortality	
Control response 1	97.5 $\pm$ 5.0 %	
Effect 2	Time to 1st brood	
Control response 2	7 d	
Effect 3	Length	
Control response 3	4.33 + 0.09 mm (cont) 4.31 + 0.09 (solvent cont)	
Temperature	20 ± 2 °C	
Test type	Flow through	
Photoperiod/light intensity	16L:8D, 40-52 footcandles surf	

Reference	Blakemore & Burgess 1990	*D. magna*
Parameter	**Value**	**Comment**
Dilution water	Blended hard + soft water	ABC well and RO
pH	7.7-8.2	
Hardness	140-168 mg/L	
Alkalinity	168-188 mg/L	
Conductivity	310-380	
Dissolved Oxygen	6.8 – 8.8 mg/L (80-104% saturation)	
Feeding	Yes 4 times a day	Algal suspension, trout chow and yeast
Purity of test substance	94%	
Concentrations measured?	Yes	
Measured is what % of nominal?	94%	
Chemical method documented?	Ext DCM, GC-FPD	
Concentration of carrier (if any) in test solutions	0.05mL/0.5L DMF	
Concentration 1 Nom/Meas (µg/L)	1 / 0.94 (0% survival)	4x 10
Concentration 2 Nom/Meas (µg/L)	0.5 / 0.46 (75% survival)	4x 10
Concentration 3 Nom/Meas (µg/L)	0.25 / 0.25 (97.5% survival)	4x 10
Concentration 4 Nom/Meas (µg/L)	0.12 / 0.10 (97.5% survival)	4x 10
Concentration 5 Nom/Meas (µg/L)	0.06 / 0.06 (100% survival)	4x 10
Control	Water Solvent (DMF)	2x 4x 10 97% survival
EC50; moving average (and binomial and probit method) 95%	0.52 (21d)	Immobilization
NOEC; moving average (p<0.05)	0.06	
LOEC; moving average (p<0.05)	0.10	
MATC (GeoMean NOEC,LOEC)	0.077	
% control at NOEC	100% survival	Control 97.5% surv
% of control LOEC	97.5 % survival	

Other notes:

- Nested experimental design
- Survival data was analyzed using frequency analysis (test conc and control). This was coupled with one-tailed Fisher's exact test and Chi-square statistics (significance)
- Reproduction data was analyzed by a t-test. A Dunnet's one-tailed multiple means comparison was used (test conc and control signif).

- Daphnid length was assessed by one-way ANOVA. A Shapiro-wilk test was used to assess conc normality

Reliability points taken off for:
Documentation: Minimum significant difference (2), % control at NOEC/LOEC (2)
Acceptability: Minimum significant difference (1)

Toxicity Data Summary

Daphnia magna

Study: Kikuchi M, Sasaki Y, Wakabayashi M. 2000. Screening of organophosphate insecticide pollution in water by using *Daphnia magna*. Ecotox Environ Safety 47:239-245.

Rating:
Relevance score: 100
Rating: R

Reliability
Score: 74.5
Rating: R

Reference	**Kikuchi *et al.* 2000**	***D. magna***
Parameter	**Value**	**Comment**
Test method cited	Japanese Industrial Standard Method	Full reference below
Phylum/subphylum	Arthropoda/Crustacea	
Class	Branchiopoda	
Order	Cladocera	
Family	Daphniidae	
Genus	*Daphnia*	
Species	*magna*	
Native to	North America	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Immobility	
Control response 1	0%	
Temperature	21^{o}C	
Test type	Static	
Photoperiod/light intensity	18L:8D (sic); perhaps 16L:8D ?	
Dilution water	Mineral water	
pH	7.4-7.9	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	7.8 mg/L	

Reference	**Kikuchi *et al.* 2000**	***D. magna***
Parameter	**Value**	**Comment**
Feeding	NR	
Purity of test substance	Analytical grade	
Concentrations measured?	No	
Measured is what % of nominal?	NA	
Chemical method documented?	NA	
Concentration of carrier (if any) in test solutions; Density of acetone = 0.8 g/mL Density of DMSO = 1.1 g/mL	< 10 mg/L; either acetone or DMSO; not specified which solvent was used for which pesticides	If DMSO: 0.009 mL/L; If acetone: 0.01 mL/L
Concentration 1 Nom (µg/L)	Number and levels NR; dilution factor = 1.8	Reps: 4 w/5 per
Control	Mineral water	Reps: 4 w/5 per
EC_{50} (95% ci); µg/L	1.8 (1.5-2.0)	Probit

Japanese Industrial Standard (JIS K 0229). 1992. Testing Methods for Determination of the Inhibition of the Mobility of *Daphnia* by Chemicals.

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Conductivity (2), Hypothesis tests (8)
Acceptability: Appropriate control (6), Measured conc w/in 20% of nominal (4), Organisms randomized (1), Hardness (2), Alkalinity (2), Temperature > +/- 1^{o}C, Conductivity (1), Adequate number of concentrations (3), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Gambusia affinis

Study: Tietze NS, Hester PG, Hallmon CF, Olson MA, Shaffer KR. 1991. Acute Toxicity of Mosquitocidal Compounds to Young Mosquitofish, Gambusia affinis. J. Am. Mosq. Control Assoc. 7:290-293.

Relevance
Score: 100
Rating: R

Reliability
Score: 78.5
Rating: R

Reference	**Tietze *et al.* 1991**	***G. affinis***
Parameter	**Value**	**Comment**
Test method cited	ASTM	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cyprinodontiformes	
Family	Poeciliidae	
Genus	*Gambusia*	
Species	*affinis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	5 d	
Source of organisms	Eggs from females cultured in ponds	
Have organisms been exposed to contaminants?	probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	24 and 48 h	
Effect 1	Immobility/ mortality	
Control response 1	< 5%	
Temperature	27 ± 0.5 °C	
Test type	Static	
Photoperiod/light intensity	16:8 light:dark	
Dilution water	Well water	
pH	NR	
Hardness	ca 150 ppm	
Alkalinity	ca 150 ppm	
Conductivity	NR	
Dissolved Oxygen	> 40%	
Feeding	None	

Reference	Tietze *et al.* 1991	*G. affinis*
Parameter	**Value**	**Comment**
Purity of test substance	Cythion®, Cythion is >90% malathion	Cythion UVL is 95%
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone: 1 mL/500mL beaker = 2mL/L	
Concentrations Nom/Meas (µg/L)	7 concentrations*	6 reps with 5 per
Control	Yes, Solvent	6 reps with 5 per
LC_{50} 24 h	12,680 (12,110-13,200) µg/L	Probit method
LC_{50} 48 h	3440 (2720-4370) µg/L	

Other notes:
Test repeated 7x each

Concentrations used can be seen in graphs an estimated as:
500, 800, 1060, 1200, 1600, 1800, 10,600, 11,400, 12,200 ug/L

emailed for missing info, esp. on control type April 21, 2009
Noor.Tietze@deh.sccgov.org
Reply on April 22: control was solvent control

Reliability points taken off for:
Documentation: Analytical method (4), Measured concentration (3), Conductivity (2), pH (3), Hypothesis tests (8)
Acceptability: Measured conc w/in 20% of nominal (4), Carrier solvent (4), Organisms randomized (1), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Gila elegans

Study: Beyers DW, Keefe TJ, Carlson CA. 1994. Toxicity of carbaryl and malathion to two federally endangered fishes, as estimated by regression and anova. *Environmental Toxicology and Chemistry* 13:101-107.

Relevance
Score: 92.5 (acute and chronic)
Rating: R

Reliability
Score:83 acute / 77.5 chronic
Rating: R

Reference	**Beyers *et al*. 1994**	***G. elegans***
Parameter	**Value**	**Comment**
Test method cited	ASTM E729-88 - acute ASTM E1241-88 - ELS	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Gila*	
Species	*elegans*	
Family in North America?	yes (Colorado river)	
Age/size at start of test/growth phase	Acute 4d – 6d old (2mg, 6.8mm) ELS 32d – 48 d old (4mg, 8.6mm)	
Source of organisms	Eggs Dexter Nat fish hatchery	
Have organisms been exposed to contaminants?	no	
Animals acclimated and disease-free?	yes	
Animals randomized?	yes	1 to 7 treatments
Test vessels randomized?	yes	2 replicates
Test duration	4 d acute 32 d ELS	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	NR	
Effect 2	Decrease in size	
Control response 2	NR	
Temperature	21.2-22.7 ^{o}C	
Test type	Renewal- 4 d acute Flow through- 32 d ELS	
Photoperiod/light intensity	16:8h light/dark	
Dilution water	Well in CSU	
pH	7.9-8.2	
Hardness	344 -378 mg/L as CaCO3	

Reference	Beyers *et al*. 1994	*G. elegans*
Parameter	**Value**	**Comment**
Alkalinity	237 – 259 mg/L as CaCO3	
Conductivity	720 – 780 uS/cm	
Dissolved Oxygen	6.1 – 7 mg/L	
Feeding	Acute 4d – no (before, during) ELS - live <24hr brine shrimp nauplii (2 to 3/day)	
Purity of test substance	93%	
Concentrations measured?	Yes	Acute – 2 times ELS – 4 times
Measured is what % of nominal?	NR	
Chemical method documented?	SPE w/ GC	
Concentration of carrier (if any) in test solutions	Acetone <0.5mL/L	
Concentration 1 Nom/Meas (µg/L)	5 conc nominal value NR, 1solv control, 1 dil water control	Acute: 2 Reps and 10 larvae ELS: 2 reps and 40 larvae
LC50	4d acute - 15.3 mg/L	Probit analysis
NOEC	Growth: 990 ug/L Survival: 2000 ug/L	hyp test - Anova
LOEC	Growth: 2000 ug/L Survival: 4060 ug/L	hyp test - Anova
MATC	Growth: 1407 ug/L Survival: 2849 ug/L	Geo Mean

Other notes:

Linear-plateau regression model was used to calculate a threshold value between NOEC and LOEC (p=0.001)
Threshold value (95%)
Growth - (521 (487, 557))
Survival - (1420 (936, 2160))

Reliability points taken off for:
<u>Documentation:</u> Nominal concentrations (3), Measured concentrations (3), Hypothesis tests (8 – acute only), Minimum significant difference (2 – chronic only), % control at NOEC/LOEC (2 – chronic only), Point estimates (8 – chronic only)
<u>Acceptability:</u> Control response (9), Measured conc w/in 20% of nominal (4), Carrier solvent (4 – chronic only), Hardness (2), Dilution factor (2), Hypothesis tests (3), Point estimates (3 – chronic only)

Toxicity Data Summary

Jordanella floridae

Study: Hermanutz RO. 1978. Endrin and Malathion Toxicity to Flagfish (Jordanella Floridae). *Archives of Environmental Contamination and Toxicology* **7:**159-168.

Relevance	Reliability
Score: 100	Score: 90
Rating: R	Rating: R

Reference	**Hermanutz 1978**	***J. floridae***
Parameter	**Value**	**Comment**
Test method cited	Mount and Brungs 1967 McKin and Benoit 1971	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cyprinodontiformes	
Family	Cyprinodontidae	
Genus	*Jordanella*	
Species	*floridae*	
Family in North America?	yes	
Age/size at start of test/growth phase	1 to 2 d – chronic 33d old – acute	
Source of organisms	Laboratory cultured fish	
Have organisms been exposed to contaminants?	no	
Animals acclimated and disease-free?	NR	
Animals randomized?	yes	
Test vessels randomized?	yes	
Test duration	Chronic - 30d Acute - 216hr	
Data for multiple times?	no	
Effect 1	Survival	
Control response 1	90-98%	
Effect 2	Growth	
Control response 2	1^{st} gen: 15.9-16.2 mm 2^{nd} gen: 22.4-22.7 mm	
Temperature	25.1-25.4 (chronic) 24.4-25.2 (acute)	
Test type	Flow-through	
Photoperiod/light intensity	16hr light: 8hr dark	
Dilution water	Lake Superior (UV sterile)	aerated
pH	7.3-7.6	
Hardness	41-46 mg/L	

Reference	**Hermanutz 1978**	***J. floridae***
Parameter	**Value**	**Comment**
Alkalinity	39 – 44 mg/L	
Conductivity	NR	
Dissolved Oxygen	>80% saturation	
Feeding	<30d – live brine shrimp nauplii Older fish – frozen brine shrimp	3 times/day
Purity of test substance	95%	
Concentrations measured?	Yes (GC)	
Measured is what % of nominal?	95% recovery for chronic	
Chemical method documented?	US EPA 1974	
Concentration of carrier (if any) in test solutions	Acetone (1.4mg/L)	Tanks 54L and 6.3L
Concentration 1 Nom/Meas (µg/L)	Chronic – 36/31.5 ± 4.4 Acute – 516 ± 32	C - 2x 20 larvae A - 40 fish
Concentration 2 Nom/Meas (µg/L)	Chronic – 27/24.7 ± 3.4 Acute – 374 ± 36	C - 2x 20 larvae A - 40 fish
Concentration 3 Nom/Meas (µg/L)	Chronic – 20.3/19.3 ± 1.6 Acute – 294 ± 9	C - 2x 20 larvae A - 40 fish
Concentration 4 Nom/Meas (µg/L)	Chronic – 15.2/15.0 ± 1.6 Acute – 233 ± 20	C - 2x 20 larvae A - 40 fish
Concentration 5 Nom/Meas (µg/L)	Chronic – 11.5/10.9 ± 0.8 Acute – 170 ± 20	C - 2x 20 larvae A - 40 fish
Concentration 6 Nom/Meas (µg/L)	Chronic – 8.5/8.6 ± 1.0 Acute – 116 ± 12	C - 2x 20 larvae A - 40 fish
Concentration 7 Nom/Meas (µg/L)	Chronic – 6.4/5.8 ± 0.6	C - 2x 20 larvae
Control	Water (no solvent)	C - 2x 20 larvae A - 40 fish
LC_{50}, probit method (95%)	96hr – 349 ug/L (383-321) 216hr – 235 ± 22 ug/L	
NOEC	Growth – 8.6 ug/L Survival – 19.3 ug/L	Method: NR, MSD: NR p:0.05
LOEC	Growth – 10.9 ug/L Survival – 24.7 ug/L	(p=0.05) one way variance
MATC (GeoMean NOEC,LOEC)	Growth – 9.68 ug/L Survival – 21.83 ug/L	
% control at NOEC	2%	
% of control LOEC	Growth – 89.4% Survival – 67.4%	

Other notes: data for ACR

Reliability points taken off for:
Documentation: Conductivity (2), Minimum significant difference (2)
Acceptability: Standard method (5), Appropriate control (6), Proper acclimation (1), Adequate replication (2), Minimum significant difference (1)

Toxicity Data Summary

Jordanella floridae

Study: Hermanutz RO, Eaton JG, Mueller LH. 1985. Toxicity of endrin and malathion mixtures to flagfish (Jordanella floridae). *Archives of Environmental Contamination and Toxicology* **14**:307-314.

Relevance
Score:100
Rating: R

Reliability
Score: 89
Rating: R

Reference	**Hermanutz *et al.* 1985**	***J. floridae***
Parameter	**Value**	**Comment**
Test method cited	Mount and Brungs 1967 McKin and Benoit 1971	APHA 1971
Phylum	Chordata	
Class	Actinopterygii	
Order	Cyprinodontiformes	
Family	Cyprinodontidae	
Genus	*Jordanella*	
Species	*floridae*	
Family in North America?	yes	
Age/size at start of test/growth phase	2 to 3 d – chronic 37d old – acute	
Source of organisms	Laboratory cultured fish	
Have organisms been exposed to contaminants?	no	
Animals acclimated and disease-free?	NR	
Animals randomized?	yes	
Test vessels randomized?	yes	
Test duration	Chronic - 140d Acute - 168hr	
Data for multiple times?	no	
Effect 1	Mortality	
Control response 1	85 ± 6.9 % survival	
Effect 2	Growth	
Control response 2	20.9 ± 3.1 mm	
Temperature	Chronic - 24.1-25.5 ^{o}C Acute – 23.4-24.5 ^{o}C	
Test type	Flow-through	
Photoperiod/light intensity	16hr light	
Dilution water	Lake Superior (UV sterile)	aerated
pH	6.9-7.8	
Hardness	43-48 mg/L	

Reference	Hermanutz *et al.* 1985	*J. floridae*
Parameter	**Value**	**Comment**
Alkalinity	39 – 45 mg/L	
Conductivity	NR	
Dissolved Oxygen	Chronic - 7.1-7.7 mg/L Acute - 97-107% sat	
Feeding	<30d – live brine shrimp nauplii Older fish – frozen brine shrimp	3 times/day
Purity of test substance	95%	
Concentrations measured?	Yes (GC-ECD)	
Measured is what % of nominal?	99-113%	
Chemical method documented?	US EPA 1974	
Concentration of carrier (if any) in test solutions	Acetone (1.9-3.5mg/L)	Tanks 54L and 6.3L
Concentration 1 Nom/Meas (μg/L)	Chronic – 35/23.1±3.1 Acute – 435/419	C - 2x 30 fish A – 2x40 fish
Concentration 2 Nom/Meas (μg/L)	Chronic – 26/18.5±2.2 Acute – 340/331	C - 2x 30 fish A – 2x40 fish
Concentration 3 Nom/Meas (μg/L)	Chronic – 20/13.8±1.4 Acute – 265/265	C - 2x 30 fish A – 2x40 fish
Control	Water (no solvent)	C - 2x 30 fish A – 2x40 fish
LC50	24hr – 320 ug/L 48hr – 280 ug/L	probit method (95%)
NOEC	Growth – 13.8 ug/L (30d)	Method: ANOVA p:0.05
LOEC	Growth – 18.5 ug/L (30d)	(p=0.05) ANOVA
MATC (GeoMean NOEC,LOEC)	Growth – 15.98 ug/L (30d)	
% control at NOEC	Growth – 95.7%	
% of control LOEC	Growth – 93.8%	

Other notes: data for ACR and mixture

Reliability points taken off for:
<u>Documentation:</u> Temperature (2), Minimum significant difference (2)
<u>Acceptability:</u> Appropriate control (6), Measured conc w/in 20% of nominal (4), Proper acclimation (1), Conductivity (1), Adequate # of concentrations (3), Dilution factor (2), Minimum significant difference (1)

Toxicity Data Summary

Lepomis macrochirus

Study: Eaton JG. 1970. Chronic Malathion Toxicity to Bluegill (Lepomis-Macrochirus-Rafinesque). *Water Research* 4:673.

<u>Relevance- ACUTE</u> Score: 82.5 (no std method, Control response NR) Rating: L	<u>Reliability</u> Score: 68 Rating: L
<u>Relevance- CHRONIC -SPAWNING</u> Score: 75 (no std method, No values) Rating: L	<u>Reliability</u> Score: 77.5 Rating: R
<u>Relevance- CHRONIC- SPINAL DEFORMATIES</u> Score: 67.5 (no std method, Control response NR, Endpoint) Rating: N	<u>Reliability</u> Score: NA Rating: NA
<u>Relevance- CHRONIC- AChE Inhibition</u> Score: 75 (no std method, Endpoint) Rating: L	<u>Reliability</u> Score: 77.5 Rating: R
<u>Relevance- CHRONIC- SURVIVAL</u> Score: 90 (no std method) Rating: **R**	<u>Reliability</u> Score: 77.5 Rating: **R**

Reference	**Eaton 1970**	***L. macrochirus***
Parameter	**Value**	**Comment**
Test method cited	APHA for Water qual only	
Phylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Centrarchidae	
Genus	*Lepomis*	
Species	*macrochirus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	8 cm, 12g, about 1.5 y	
Source of organisms	Spring fed ponds	
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	Acute: 96 h	Nov 11- Sept 5

Reference	**Eaton 1970**	***L. macrochirus***
Parameter	**Value**	**Comment**
	Chronic: 10 mo	
Data for multiple times?	NR	
Effect 1	Acute test-lethality	
Control response 1	NR	
Effect 2	Chronic –Reproduction: # spawning, %hatch, fry survival	No sig. effects seen
Control response 2	1.5 and 1.4 spawn/female, 93, 85% hatch survival, 700, 1400 # fry hatched	
Effect 3	Chronic spinal deformities	
Control response 3	NR	
Effect 4	Adult survival	
Control response 4	None by Sept 5,but fish that jumped out of tank	
Temperature	9-29 °C subject to ambient fluctuation over several months	
Test type	Flow-trough	
Photoperiod/light intensity	Ambient	
Dilution water	Described in a cited ref.	
pH	7.2-8.5	
Hardness	194-218 mg/L as $CaCO_3$	
Alkalinity	144-186 mg/L as $CaCO_3$	
Conductivity	372-526 umOhms	
Dissolved Oxygen	3.3-16.3 but mostly > 5 mg/L	
Feeding	Chronic: yes, acute: not	
Purity of test substance	95 %	
Concentrations measured?	Yes	
Measured is what % of nominal?	70-83%	
Chemical method documented?	Yes, GC ECD	
Concentration of carrier (if any) in test solutions	< 0.001 mg/L acetone <0.01 uL/L	
ACUTE	4-5 concentrations dilution factor of 0.75. Measured concentrations, but concentrations or % nom NR	10 fish /conc.
CHRONIC		
Concentration 1 Nom/Meas (μg/L)	80/66 (all fish died)	15 fish per conc. in 1 tank, later split
Concentration 2 Nom/Meas (μg/L)	40/28 (all fish died)	

Reference	Eaton 1970	*L. macrochirus*
Parameter	**Value**	**Comment**
Concentration 3 Nom/Meas (μg/L)	20/14.6 (5/15 fish died)	into 2 tanks: 1 indoors and 1 outdoors
Concentration 4 Nom/Meas (μg/L)	10/7.4	
Concentration 5 Nom/Meas (μg/L)	5/3.6	
Concentration 6 Nom/Meas (μg/L)	2.5/ 1.6	
Concentration 7 Nom/Meas (μg/L)	1.25/ 0.7	
Control	Yes, dilution water only	Same as above
LC_{50}	Test 1: 131 ug/L Test 2: 89 ug/L	Graphical interpolation
AChE Inhibition 52%	20/ 14.6 ug/L (Nom/Meas)	
AChE Inhibition 54%	10/7.4ug/L	
AChE Inhibition 67%	5/3.6	
AChE Inhibition 65%	2.5/ 1.6	
AChE Inhibition 79%	1.25/ 0.7	
NOEC	3.6 ug/L- spinal def. 7.4 ug/L - survival	Method: no stats, just observation p: NR MSD: NR
LOEC	7.4 ug/L-spinal def 14.6 ug/L- survival	Method: no stats, just observation p: NR MSD: NR
MATC (GeoMean NOEC,LOEC)	5.2 ug/L-spinal def 10.4 ug/L- survival	
% control at NOEC	NR	
% of control LOEC	NR	

Other notes:
Experiment started in glass tanks. Then fish were dived into indoor stainless steel tanks and outdoor wooden tanks to provide more room for spawning. Sex was not really distinguishable, so it ended up that males were mostly moved out side and most of those left inside were females. Outdoors (wooden tanks) 7 males to 2 females was a common sex ratio. Indoors the sex ratio was more variable in all the different concentrations (Table 4).
No effect of malathion on spawning is apparent from TABLE 5. Early (larval) fry survival in all but one case was nearly as good as or better than the controls, indicating that malathion in concentrations up to 20 ug/L had no effect on survival up to 4 days after hatch (TABLE 5).

Effects seen on adult survival:
"The 80-and 40-ug/L concentrations were discontinued after all the fish died. The lethality of the highest concentration was determined twice; 15 fish were killed in 14 days in the first test and in 16 days in the second. All 15 fish were killed in 54 days in the 40 ug/L tank. Two new concentrations, 1.25 and 2.5/~g 1-1, were added at

this time lest none of the original ones would still be safe at the end of the chronic test period. The first death in 20 ug/L occurred on January 6 after 56 days of exposure, but 10 fish were still alive at the end of the test on September 5. The only other mortality in the test tanks resulted when a fish jumped out of the outdoor (wooden) control tank."

Although no adult fish were killed in the 10 ug /L tanks, two inside and three outside (one-third of the total) had spinal deformations, as did 60 per cent of those remaining alive in 20/~g 1-1. This is the basis for the NOEC and LOEC reported in the abstract. But reproduction not affected.

"As pointed out by WEISS (1959, 1961), LELAND (1968), GIBSON *et al* (1969), and others, the degree of inhibition by an organophosphate pesticide is dependent upon its concentration, the fish species involved, the duration of the exposure, and other factors not well understood."

Reliability points taken off **chronic** test for:
Documentation: Dilution water (3), Hypothesis tests (6)
Acceptability: Standard method (5), Appropriate control (6), Measured conc w/in 20% of nominal (4), Organisms randomized (1), Dilution water (2), Dissolved oxygen (6), Temperature >/- 1^{o}C (3), Random design (2), Adequate replication (2), Statistics method (2), Minimum significant difference (1)

Toxicity Data Summary

Morone saxatilis

Study: Fujimura R, Finlayson B, Chapman G. 1991. Evaluation of acute and chronic toxicity tests with larval striped bass. In: Mayes MA, Barron MG (eds). *Aquatic Toxicology and Risk Assessment*. ASTM, Philadelphia, PA, pp 193-211.

Note: Acute test with stripped bass is the only test with malathion. None of the chronic studies were conducted with malathion

<u>Relevance-Acute 96 h test</u>
Score: 92.5 (Control response NR)
Rating:R

<u>Reliability</u>
Score: 73.5
Rating: R

Reference	**Fujimura *et al.* 1991**	***M. saxatilis***
Parameter	**Value**	**Comment**
Test method cited	ASTM	
Phylum	Chordata	
Class	Actinopterygii	
Order	Perciformes	
Family	Moronidae	
Genus	*Morone*	
Species	*saxatilis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Acute: 6-45 d post hatch	
Source of organisms	Larval st. bass - CDFG hatchery	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	96 h acute 35-52 d chronic	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	NR	
Temperature	ATL:17-19 (depending on test) ± 0.5 °C	
Test type	Flow through	
Photoperiod/light intensity	NR	
Dilution water	ATL: Filtered degassed ground water, adjusted to 1-2 ppt salinity with artificial sea salt mix EPA: Epa reconstituted water	

Reference	**Fujimura *et al.* 1991**	***M. saxatilis***
Parameter	**Value**	**Comment**
pH	ATL:7.8-8.2 EPA: 8.1	
Hardness	ATL: 110-140 mg/L as CaCO3 EPA:	
Alkalinity	ATL:110-150 mg/L as CaCO3 EPA: 150	
Conductivity	NR	
Dissolved Oxygen	Monitored daily, but NR	
Feeding	Yes in acute & chronic	
Purity of test substance	94.2% technical	
Concentrations measured?	Yes	
Measured is what % of nominal?	NR	
Chemical method documented?	Yes	
Concentration of carrier (if any) in test solutions	≤ 0.5mL/L Triethylene glycol methyl ether: triethylene glycol (1:10	
Acute test		
Concentration 1 Nom/Meas (µg/L)	5 concentration, plus control	2 reps with 20-25 larvae
Control	Water only, but in 1989, Solvent control	2 reps with 20-25 larvae
LC50 (SD), 96 h:	Listed below	Moving average analysis

Year of Test	**96 h LC_{50} (SD)**	**Age (day post hatch)**
1988	16 (13-19)	11 d
1988	25 (19-34)	45 d
1988	12 (11-14)	29 d
1989	64 (55-77)	13 d
1989	100 (87-150)	45 d
1989	66 (58-74)	45 d

Reliability points taken off for:
Documentation: Nominal concentrations (3), Measured concentrations (3), Dissolved oxygen (4), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Measured conc w/in 20% of nominal (4), Appropriate feeding (3), Dissolved oxygen (6), Conductivity (1), Photoperiod (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Neomysis mercedis

Brandt OM, Fujimura RW, Finlayson BJ. 1993. Use of *Neomysis mercedis* (Crustacea: Mysidacea) for estuarine toxicity tests. Transactions of the American Fisheries Society 122:279-288.

Relevance
Score: 92.5 (Control response NR)
Rating: R

Reliability
Score: 75
Rating: R

Reference	**Brandt *et al.* 1993**	***N. mercedis***
Parameter	**Value**	**Comment**
Test method cited	ASTM	
Phylum	Arthropoda	
Class	Crustacea	
Order	Malacostraca	
Family	Mysidacea	
Genus	*Neomysis*	
Species	*mercedis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Neonates: ≤ 5d Juveniles: > 15d	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	Yes	
Test duration	96 h	
Data for multiple times?	No	
Effect 1	mortality	
Control response 1	NR	
Temperature	17 ± 0.5 °C	
Test type	Flow through	
Photoperiod/light intensity	NR	
Dilution water	Well water, degassed, aerated, filtered	
pH	Monitored daily but NR	
Hardness	Monitored daily but NR	
Alkalinity	Monitored daily but NR	
Conductivity	Salinity: 2ppt	
Dissolved Oxygen	Monitored daily but NR	
Feeding	Yes	

Reference	**Brandt *et al.* 1993**	***N. mercedis***
Parameter	**Value**	**Comment**
Purity of test substance	94.2%	
Concentrations measured?	Yes	
Measured is what % of nominal?	94%	
Chemical method documented?	Yes	
Concentration of carrier (if any) in test solutions	≤ 0.5 mL/L of a 1:10 mix of triethylene glycol dimethyl ether and triethylene glycol	
Concentration 1 Meas (μg/L)	5 concentrations –Meas.	2 reps and NR per
Control	Solvent (some tests didn't have solvent control) water only	2 reps and NR per
LC_{50}; indicate calculation method	By life-stage, below	
Juvenile	3.8 (2.9-5.3) μg/L	Moving ave. or nonlinear interp.
Neonate	2.2 (2.0-2.5) μg/L	
Neonate	1.5 (1.2-1.8) μg/L	(3 Repeated tests)
Neonate	1.4 (1.3-1.5) μg/L	

Other notes:

Reliability points taken off for:
Documentation: Nominal concentrations (3), Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), pH (3), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Organisms randomized (1), Adequate number per rep (2), Appropriate feeding (3), Photoperiod (2), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Oncorhynchus clarki

Study: Post G, Schroeder T. 1971. The toxicity of four insecticides to four Salmonid species. Bulletin of Environmental Contamination and Toxicology 6:144-155.

Relevance	Reliability
Score: 92.5 (Control response NR)	Score: 75.5
Rating:R	Rating:R

Reference	**Post & Schroeder 1971**	***O. clarki***
Parameter	**Value**	**Comment**
Test method cited	APHA	
Phylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*clarki*	cutthroat trout
Family in North America?	Yes	
Age/size at start of test/growth phase	Test 1:0.33g, Test 2: 1.25 g	
Source of organisms	Hatcheries	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	72, 96 h	
Effect 1	Mortality	
Control response 1	NR	
Temperature	12.9 °C	
Test type	Static renewal 24 h	
Photoperiod/light intensity	NR	
Dilution water	well	
pH	7.2-7.6	
Hardness	318-348 mg/L as CaCO3	
Alkalinity	276-348 mg/L as CaCO3	
Conductivity	NR	
Dissolved Oxygen	5.9-6.0 mg/L	
Feeding	None	
Purity of test substance	95 %	
Concentrations measured?	NR	

Reference	**Post & Schroeder 1971**	***O. clarki***
Parameter	**Value**	**Comment**
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone -concentrations NR	
Concentration 1 Nom/Meas (μg/L)	5-6	2 Reps and 10 per
Control	Solvent control	2 Reps and 10 per
LC50; 72 h (μg/L)	Test 1: 200 (163-245)*	Probit method
LC50; 96 h (μg/L)	Test 1: 150 (133-170)* Test 2: 201 (175-231)	

Other notes:
* only one replicate

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Measured conc w/in 20% nominal (4), Carrier solvent (4), Organism randomized (1), Conductivity (1), Photoperiod (2), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Oncorhynchus kisutch

Study: Post G, Schroeder T. 1971. The toxicity of four insecticides to four Salmonid species. Bulletin of Environmental Contamination and Toxicology 6:144-155.

Relevance
Score: 92.5 (Control response NR)
Rating: R

Reliability
Score: 75.5
Rating: R

Reference	**Post & Schroeder 1971**	***O. kisutch***
Parameter	**Value**	**Comment**
Test method cited	APHA	
Phylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	*kisutch*	*Coho salmon*
Family in North America?	Yes	
Age/size at start of test/growth phase	1.70g,	
Source of organisms	Hatcheries	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	24, 96 h	
Effect 1	Mortality	
Control response 1	NR	
Temperature	12.9 °C	
Test type	Static renewal 24 h	
Photoperiod/light intensity	NR	
Dilution water	well	
pH	7.2-7.6	
Hardness	318-348 mg/L as CaCO3	
Alkalinity	276-348 mg/L as CaCO3	
Conductivity	NR	
Dissolved Oxygen	5.9-6.0 mg/L	
Feeding	None	
Purity of test substance	95 %	
Concentrations measured?	NR	

Reference	Post & Schroeder 1971	*O. kisutch*
Parameter	**Value**	**Comment**
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone -concentrations NR	
Concentration 1 Nom/Meas (μg/L)	5-6	2 Reps and 10 per
Control	Solvent control	2 Reps and 10 per
LC50; 24 h (μg/L)	300 (211-346)	Probit method
LC50; 96 h (μg/L)	130 (208-388)	Probit method

Other notes:

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Measured conc w/in 20% nominal (4), Carrier solvent (4), Organism randomized (1), Conductivity (1), Photoperiod (2), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Oncorhynchus mykiss

Study: Cohle P. 1989. Early Life Stage Toxicity of cythion to rainbow trout (Oncorhynchus mykiss) in a flow-through system. In *Malathion registration standard*, Analytical Bio-Chemistry laboratories, Inc.: Columbia, MO. MRID 41422401.

Relevance
Score: 100
Rating: R

Reliability
Score: 92
Rating: R

Reference	**Cohle 1989**	***O. mykiss***
Parameter	**Value**	**Comment**
Test method cited	ASTM E-47.01 USEPA fry stages freshwater fish	
Phylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	
Species	Oncorhynchus mykiss	
Family in North America?	Yes	
Age/size at start of test/growth phase	Eggs 8hr post fertilization	
Source of organisms	Mt Lassen trout farm, CA	
Have organisms been exposed to contaminants?	no	
Animals acclimated and disease-free?	yes	
Animals randomized?	Yes	
Test vessels randomized?	Yes	
Test duration	97 days (37+ 60 d post hatch)	04/27 – 08/02
Data for multiple times?	Yes (37 to 60d)	
Effect 1	Hatchability (up to 37d)	Not significant to do dose response
Control response 1	94% hatched	
Effect 2	Growth	
Control response 2	37d Length (mm): 30.4 $\pm$ 2.0 (cont), 31.1 $\pm$ 1.9 (solvent cont) 60d Length (mm): 41.2 $\pm$ 4.3 (cont), 42.8 $\pm$ 3.3 (solvent cont) 60d Wet Weight (mg): 107 $\pm$ 26 (cont), 122 $\pm$ 21 (solvent cont)	
Effect 3	Fry survival	(at 37 and 60d)
Control response 3	37d: 83% (cont), 92% (solvent cont) 60d: 82% (cont), 90% (solvent cont)	
Temperature	7.8-13.6 oC	

Reference	**Cohle 1989**	***O. mykiss***
Parameter	**Value**	**Comment**
Test type	Flow through ELS	
Photoperiod/light intensity	16hr day / 131 footcandles	
Dilution water	Well water, RO + blended	
pH	7.4-8.1	
Hardness	24-52 mg/L	
Alkalinity	36-60 mg/L	
Conductivity	67-122	
Dissolved Oxygen	6.6-10.2 mg/L	65 to 94% sat at 10C
Feeding	Live brine shrimp nauplii Add ground salmon starter	Begin 46d After 54d - 3x day
Purity of test substance	94%	
Concentrations measured?	yes	
Measured is what % of nominal?	99 - 110%	
Chemical method documented?	GC/FPD	
Concentration of carrier (if any) in test solutions	DMF (50 uL into 4L)	
Concentration 1 Nom/Meas (μg/L)	5 / 5.1	4 x 35 eggs 4 x 15 larvae (after 39d)
Concentration 2 Nom/Meas (μg/L)	10 / 9.9	4 x 35 eggs 4 x 15 larvae (after 39d)
Concentration 3 Nom/Meas (μg/L)	20 / 21	4 x 35 eggs 4 x 15 larvae (after 39d)
Concentration 4 Nom/Meas (μg/L)	40 / 44	4 x 35 eggs 4 x 15 larvae (after 39d)
Concentration 5 Nom/Meas (μg/L)	80 / 84	4 x 35 eggs 4 x 15 larvae (after 39d)
Control	Water, solvent	2x 4 x 35 eggs 2x 4 x 15 larvae (after 39d)
NOEC	21 ug/L measured	ANOVA, (p<0.05) Tukey's mean comparison
LOEC	44 ug/L	ANOVA, (p<0.05)
MATC (GeoMean NOEC,LOEC)	30.4 ug/L	

Other notes:

Reliability points taken off for:
Documentation: Minimum significant difference (2), % control at NOEC/LOEC (2), Point estimates (8)
Acceptability: Minimum significant difference (1), Point estimates (3)

Toxicity Data Summary

Oncorhynchus mykiss

Study: Post G, Schroeder T. 1971. The toxicity of four insecticides to four Salmonid species. Bulletin of Environmental Contamination and Toxicology 6:144-155.

Relevance
Score: 92.5 (Control response NR)
Rating: R

Reliability
Score: 75.5
Rating: R

Reference	**Post & Schroeder 1971**	***O. mykiss***
Parameter	**Value**	**Comment**
Test method cited	APHA	
Phylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Oncorhynchus*	Rainbow trout
Species	*mykiss*	
Family in North America?	Yes	
Age/size at start of test/growth phase	0.41g,	
Source of organisms	Hatcheries	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	24, 48,72, 96 h	
Effect 1	Mortality	
Control response 1	NR	
Temperature	12.9 °C	
Test type	Static renewal 24 h	
Photoperiod/light intensity	NR	
Dilution water	well	
pH	7.2-7.6	
Hardness	318-348 mg/L as CaCO3	
Alkalinity	276-348 mg/L as CaCO3	
Conductivity	NR	
Dissolved Oxygen	5.9-6.0 mg/L	
Feeding	None	
Purity of test substance	95 %	
Concentrations measured?	NR	

Reference	Post & Schroeder 1971	*O. mykiss*
Parameter	**Value**	**Comment**
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone -concentrations NR	
Concentration 1 Nom/Meas (μg/L)	5-6; values not reported	2 Reps and 10 per
Control	Solvent control	2 Reps and 10 per
LC50; 24h	240 (198-291) μg/L	Probit method
LC50; 48 h	196 (165-223) μg/L	Probit method
LC50; 72 h	175 (146-209) μg/L	Probit method
LC50; 96 h	122 (98-153) μg/L	Probit method

Other notes:

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Measured conc w/in 20% nominal (4), Carrier solvent (4), Organism randomized (1), Conductivity (1), Photoperiod (2), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Pimephales promelas

Study: Geiger DL, Call DJ, Brooke LT. 1984. Acute toxicities of organic chemicals to fathead minnows (*Pimephales promelas*). Vol 4. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. pp 235-236.

Relevance-mortality
Score: 90 (No standard method)
Rating: R

Relevance—sublethal effects
Score: 75 (No standard method; Endpoints not linked to survival, growth, reproduction)
Rating: L

Reliability -- mortality & sublethal effects
Score: 80.5
Rating: R

Geiger et al. 1988	**Geiger *et al.* 1984**	***P. promelas***
Parameter	**Value**	**Comment**
Test method cited	No standard method cited	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Pimephales*	
Species	*promelas*	
Found in N. America?	Yes	
Age/size at start of test/growth phase	29-30 d; 0.069 ($\pm$0.032)g; 1.7 ($\pm$0.2) cm	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes, see below	
Effect 1	Mortality	
Control response 1	0%	
Effect 2	Loss of equilibrium, spinal deformities, behavioral abnormalities, hemorrhaging	

Geiger et al. 1988	Geiger *et al.* 1984	*P. promelas*
Parameter	**Value**	**Comment**
Control response 2	0% affected fish	
Temperature	25.1 $\pm$ 0.19	
Test type	Flow-through	
Photoperiod/light intensity	NR	
Dilution water	Lake Superior or dechlorinated tap water (waters shown to be very similar)	
pH	7.7 $\pm$ 0.06	
Hardness	46.9 mg/L as $CaCO_3$	
Alkalinity	44.5 mg/L as $CaCO_3$	
Conductivity	NR	
Dissolved Oxygen	6.8 $\pm$ 0.27	
Feeding	None	
Purity of test substance	95 %	
Concentrations measured?	Yes	
Measured is what % of nominal?	102.6%	
Chemical method documented?	Yes	
Concentration of carrier (if any) in test solutions	None used	
Concentration 1 Nom/Meas (mg/L)	3.18/3.15 (A)	Reps: 1 w/20 per
Concentration 2 Nom/Meas (mg/L)	4.90/4.73 (B)	Reps: 1 w/20 per
Concentration 3 Nom/Meas (mg/L)	7.54/7.53 (C)	Reps: 1 w/20 per
Concentration 4 Nom/Meas (mg/L)	11.6/11.3 (D)	Reps: 1 w/20 per
Concentration 5 Nom/Meas (mg/L)	17.8/18.5 (E)	Reps: 1 w/20 per
Control	Dilution water	Reps: 1 w/20 per
LC50 (95% ci); mg/L	14.1 (12.3-16.1)	Trimmed Spearman-Karber
EC50 (95% ci); mg/L	10.6 (9.07-12.4)	Trimmed Spearman-Karber

Mortalities by concentration and day (20 fish per concentrations at start):

	Control	A	B	C	D	E
24 h	0	0	0	0	0	0
48 h	0	1	1	1	1	11
72 h	0	1	1	1	3	13
96 h	0	1	1	1	5	15

Reliability points taken off for:
Documentation: Conductivity (2), Photoperiod (3), Hypothesis tests (8)

Acceptability: Standard method (5), Concentrations exceed 2x solubility (4), Conductivity (1), Photoperiod (2), Random design (2), Adequate replication (2), Hypothesis tests (3)

Toxicity Data Summary

Pteronarcys californica

Study: Jensen LD, Gaufin AR. 1964a. Effects of Ten Organic Insecticides on Two Species of Stonefly Naiads. Trans. Am. Fish. Soc. 93:27-34.

Relevance	Reliability
Score: 92.5 (Control response NR)	Score: 74
Rating: R	Rating: R

Reference	**Jensen & Gaufin 1964a**	***P. californica***
Parameter	**Value**	**Comment**
Test method cited	APHA	
Phylum	Arthropoda	
Class	Insecta	
Order	Neoptera	
Family	Pteronarcyidae	
Genus	*Pteronarcys*	
Species	*californica*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Naiads, 4-6 cm	
Source of organisms	Collected from field, same as dilution water source	
Have organisms been exposed to contaminants?	Possibly	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	Yes 48, 72, 96 h	
Effect 1	Mortality	
Control response 1	NR	
Temperature	11-12°C	
Test type	Static	
Photoperiod/light intensity	NR	
Dilution water	Mill creek, near Salt lake City Utah	
pH	7.9-8.3	
Hardness	122-210 mg/L	
Alkalinity	150 -220 m/L	
Conductivity	NR	
Dissolved Oxygen	7.4-13.5 (initial)	NR during test, but they describe

Reference	**Jensen & Gaufin 1964a**	***P. californica***
Parameter	**Value**	**Comment**
		bubbling in compressed air to maintain DO-acceptable
Feeding	None	
Purity of test substance	95%	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone and emulsifier, up to 56 mg/L (0.056 mL/L, if density 1 g/mL)	
Concentration 1 Nom/Meas (μg/L)	5 concentrations, 10-100 ug/L	2 Reps and 10 per
Control	Yes, states species unaffected by solvent & emulsifier so used solvent control (?)	Reps and # per (cell density for single
LC_{50}	(Listed below)	Graphical interpolation
48 h	180	
72 h	72.5	
96 h	50.0	

Other notes:
Also reports effects on activity, loss of equilibrium, tremors and convulsions, and death, but only at one concentration (18 ug/L).

Reliability points taken off for:
<u>Documentation:</u> Analytical method (4), Measured concentrations (3), Dissolved oxygen (4), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
<u>Acceptability:</u> Control response (9), Measured conc w/in 20% nominal (4), Prior contamination (4), Organisms randomized (1), Dilution water (2), Conductivity (1), Photoperiod (2), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Pteronarcys californica

Study: Jensen LD, Gaufin AR. 1964b. Long-Term Effects of Organic Insecticides on Two Species of Stonefly Naiads. Trans. Am. Fish. Soc. 93:357-363.

Relevance; 4d(96h) LC50	Reliability
Score: 90 (no std method)	Score: 77
Rating: R	Rating: R
Relevance; 5d-30d LC50- Value not appropriate for chronic distribution	Reliability
Score: 90 (no std method)	Score: 77
Rating: R	Rating: R
Relevance; 30d NOEC/LOEC	Reliability
Score: 75 (no std method, No values)	Score: 73.5
Rating: L	Rating: R

NOEC LOEC aren't calculated but can be estimated from graph. Only LC_{50} are calculated and reported as tox values.

Reference	**Jensen & Gaufin 1964b**	***P. californica***
Parameter	**Value**	**Comment**
Test method cited	APHA	More just for data analysis
Phylum	Arthropoda	
Class	Insecta	
Order	Amphipoda	
Family	Pteronarcyidae	stonefly
Genus	*Pteronarcys*	
Species	*californica*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Naiad	
Source of organisms	Collected from field, same as dilution water source	Reported in Jensen&Gaufin 1964a
Have organisms been exposed to contaminants?	Maybe because collected from field	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	30 d	
Data for multiple times?	Yes: 4,5,10,15,20,25,30 d	
Effect 1	Mortality	
Control response 1	No effect *	

Reference	Jensen & Gaufin 1964b	*P. californica*
Parameter	**Value**	**Comment**
Temperature	12.8 ± 0.6 °C	
Test type	Flow though	
Photoperiod/light intensity	NR	
Dilution water	Mill creek, near Salt lake City Utah	Reported in Jensen&Gaufin 1964a
pH	7.8-8.2	
Hardness	NR	
Alkalinity	165-225 m/L	
Conductivity	NR	
Dissolved Oxygen	9-11 mg/L	
Feeding	None	
Purity of test substance	95%	
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	50 mg/L	
Concentration 1 Nom/Meas (μg/L)	8 concentrations, values NR	reps and 25 per
Control	Yes *	reps and 25 per
LC50 4 day	Not calculable	
LC50 15-d	45.00 μg/L	
LC50 20-d	24.00 μg/L	
LC50 25-d	15.50 μg/L	
LC50 30-d	8.80 μg/L ***	
NOEC	4 μg/L**	Method: no stats p: none MSD: none
LOEC; indicate calculation method	5 μg/L **	
MATC (GeoMean NOEC,LOEC)	4.5 μg/L **	
% control at NOEC	NR	
% of control LOEC	NR	

*States: exposure of both species to acetone and water for 30-d periods within a range of concentration of 5.0 to 50.0 ppm of acetone had no noticeable affect on either species.
**Values estimated from graph, not statically determined
***5-30d LC50- Value is calculated, but not appropriate for chronic distribution or ACR

Reliability points taken off for:
<u>Documentation:</u> Analytical method (4), Measured concentrations (3), Hardness (2), Conductivity (2), Photoperiod (3), Hypothesis tests (6)
<u>Acceptability:</u> Appropriate duration (2), Appropriate control (6), Control response (9), Measured conc w/in 20% nominal (4), Prior contamination (4), Organisms randomized

(1), Dilution water (2), Hardness (2), Conductivity (1), Photoperiod (2), Random design (2), Dilution factor (2), Minimum significant difference (1)

Toxicity Data Summary

Ptychocheilus lucius

Study: Beyers DW, Keefe TJ, Carlson CA. 1994a. Toxicity of carbaryl and malathion to two federally endangered fishes, as estimated by regression and anova. *Environmental Toxicology and Chemistry* 13:101-107.

Relevance
Score: 92.5 (acute and chronic)
Rating: R

Reliability
Score: 83 acute / 77.5 chronic
Rating: R

Reference	**Beyers *et al*. 1994a**	***P. lucius***
Parameter	**Value**	**Comment**
Test method cited	ASTM E729-88 - acute ASTM E1241-88 - ELS	
Phylum	Chordata	
Class	Actinopterygii	
Order	Cypriniformes	
Family	Cyprinidae	
Genus	*Ptychocheilus*	
Species	*lucius*	
Family in North America?	yes (Colorado river)	
Age/size at start of test/growth phase	Acute 4d – 26d old (4mg, 9.4mm) Chronic Early Life Stage (ELS) 32d – 41d old (9 mg, 12mm)	Acute - 10x2 /conc
Source of organisms	Eggs Dexter Nat fish hatchery	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	1 of 7 treatments
Test vessels randomized?	Yes	2 replicates
Test duration	4 d acute 32 d chronic	
Data for multiple times?	Yes	
Effect 1	Mortality	
Control response 1	NR	
Effect 2	Decrease in size	
Control response 2	NR	
Temperature	22 ±1 ^{o}C	
Test type	Renewal- 4 d acute Flow through- 32 d ELS	
Photoperiod/light intensity	16:8h light:dark	
Dilution water	From well at CSU	

Reference	Beyers *et al*. 1994a	*P. lucius*
Parameter	**Value**	**Comment**
pH	8.5-8.6	
Hardness	212 – 216 mg/L CaCO3	
Alkalinity	104 – 110 mg/L CaCO3	
Conductivity	600 uS/cm	
Dissolved Oxygen	7.1 – 7.2 mg/L	
Feeding	Acute 4d – no (before, during) ELS - live <24hr brine shrimp nauplii (2 to 3/day)	
Purity of test substance	93%	
Concentrations measured?	Yes	Acute – 2 times ELS – 4 times
Measured is what % of nominal?	NR	
Chemical method documented?	SPE with GC	
Concentration of carrier (if any) in test solutions	Acetone < 0.5mL/L	
Concentration 1 Nom/Meas (µg/L)	5 conc nominal value NR, 1solv control, 1 dil water control	Acute: 2 Reps and 10 larvae ELS: 2 reps and 30 larvae
LC50 (95% CI) mg/L	4d acute - 9.14 (8.36-10.0)	Probit analysis
NOEC	Growth: 1680 ug/L Survival: 1680 ug/L	1) hyp test - Anova
LOEC	Growth: 3510 ug/L Survival: 3510 ug/L	Hyp test
MATC	Growth: 2428 ug/L Survival: 2428 ug/L	Geo mean

Other notes:

ACR values

Linear-plateau regression model was used to calculate a threshold value between NOEC and LOEC (p=0.001)
Threshold value (95%)
Growth - 1470 ug/L (1410, 1520)
Survival - 455 ug/L (236, 786)

Reliability points taken off for:
Documentation: Nominal concentrations (3), Measured concentrations (3), Hypothesis tests (8 – acute only), Minimum significant difference (2 – chronic only), % control at NOEC/LOEC (2 – chronic only), Point estimates (8 – chronic only)
Acceptability: Control response (9), Measured conc w/in 20% of nominal (4), Carrier solvent (4 – chronic only), Hardness (2), Dilution factor (2), Hypothesis tests (3), Point estimates (3 – chronic only)

Toxicity Data Summary

Rana palustris

Study: Budischak SA, Belden LK, Hopkins WA. 2009. Relative Toxicity of Malathion to Trematode-Infected and Noninfected *Rana palustris* Tadpoles. Arch Environ Contam Toxicol 56:123–128

Relevance
Score: 100
Rating: R

Reliability
Score: 84
Rating: R

Reference	**Budischak *et al.* 2009**	***R. palustris***
Parameter	**Value**	**Comment**
Test method cited	ASTM	
Phylum	Chordata	
Class	Amphibia	
Order	Anura	
Family	Ranidae	
Genus	*Rana*	
Species	*palustris*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Gosner stage 26	
Source of organisms	Eggs collected from pond	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	Yes	
Animals randomized?	Yes	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	0 % mortality	
Temperature	16.57 ± 0.04°C	
Test type	Static	
Photoperiod/light intensity	16:8 light: dark	
Dilution water	75/25 mix of dechloraminated town water and well water	
pH	7.29	
Hardness	172 mg/L	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	96.8 % - 86.3 %	
Feeding	None	
Purity of test substance	98 %	

Reference	Budischak *et al.* 2009	*R. palustris*
Parameter	**Value**	**Comment**
Concentrations measured?	Yes	
Measured is what % of nominal?	> 80%	
Chemical method documented?	No	
Concentration of carrier (if any) in test solutions	0.4% methanol ~4 mL/L	
Concentration 1 Nom/Meas (μg/L)	40,000 / 40,000	3 reps with 10 per
Concentration 2 Nom/Meas (μg/L)	24000	3 reps with 10 per
Concentration 3 Nom/Meas (μg/L)	14400 /14500	3 reps with 10 per
Concentration 4 Nom/Meas (μg/L)	8640	3 reps with 10 per
Concentration 5 Nom/Meas (μg/L)	5200 /5000	3 reps with 10 per
Control	Water only and solvent control	3 reps with 10 per
LC50	17,100 ug/L	Spearman–Karber

Other notes: emailed author to obtain original LC_{50} values, since study only provides a range, 16,500–17,400 ug/L, which Includes tadpoles infected with trematodes (tramatodes were found not to significantly affect malathion toxicity, so all LC_{50} values were reported together. The values were reported as a range not a mean, therefore the author was contacted to obtain a single value.)

The LC50 for the uninfected tadpoles was 17.1 mg/L
Hopkins, William: hopkinsw@vt.edu

Reliability points taken off for:
Documentation: Analytical method (4), Alkalinity (2), Conductivity (2), Hypothesis tests (8)
Acceptability: Carrier solvent (4), Prior contaminant exposure (4), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Salvelinus fontinalis

Study: Post G, Schroeder T. 1971. The toxicity of four insecticides to four Salmonid species. Bulletin of Environmental Contamination and Toxicology 6:144-155.

Relevance
Score: 92.5 (Control response NR)
Rating: R

Reliability
Score: 75.5
Rating: R

Reference	**Post & Schroeder 1971**	***S. fontinalis***
Parameter	**Value**	**Comment**
Test method cited	APHA	
Phylum	Chordata	
Class	Actinopterygii	
Order	Salmoniformes	
Family	Salmonidae	
Genus	*Salvelinus*	
Species	*fontinalis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Test 1:1.15g, Test 2: 2.13 g	
Source of organisms	Hatcheries	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	96 h	
Data for multiple times?	72, 96 h	
Effect 1	Mortality	
Control response 1	NR	
Temperature	12.9 °C	
Test type	Static renewal 24 h	
Photoperiod/light intensity	NR	
Dilution water	Well	
pH	7.2-7.6	
Hardness	318-348 mg/L as $CaCO_3$	
Alkalinity	276-348 mg/L as $CaCO_3$	
Conductivity	NR	
Dissolved Oxygen	5.9-6.0 mg/L	
Feeding	None	
Purity of test substance	95 %	

Reference	Post & Schroeder 1971	*S. fontinalis*
Parameter	**Value**	**Comment**
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone -concentrations NR	
Concentration 1 Nom/Meas (μg/L)	5-6	2 Reps and 10 per
Control	Solvent control	2 Reps and 10 pe
LC50; 72 h (μg/L)	Test 1: 160 (144-182) Test 2: 150 (104-216)	Probit method
LC50; 96 h (μg/L)	Test 1: 130 (110-154) Test 2: 120 (96-153)	

Other notes:

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Conductivity (2), Photoperiod (3), Hypothesis tests (8)
Acceptability: Control response (9), Measured conc w/in 20% nominal (4), Carrier solvent (4), Organism randomized (1), Conductivity (1), Photoperiod (2), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Simulium vittatum

Study: Overmyer JP, Armbrust KL, Noblet R. 2003. Susceptibility of black fly larvae (Diptera : Simuliidae) to lawn-care insecticides individually and as mixtures. Environ Toxicol. Chem. 22:1582-1588.

Relevance
Score: 100
Rating: R

Reliability
Score: 86.5
Rating: R

Reference	**Overmyer *et al.* 2003**	***S. vittatum***
Parameter	**Value**	**Comment**
Test method cited	EPA	
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Simuliidae	
Genus	*Simulium*	
Species	*vittatum*	
Family in North America?	Yes	
Age/size at start of test/growth phase	6 and 7th instar	
Source of organisms	Lab culture	
Have organisms been exposed to contaminants?	Probably not	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	< 10%	
Temperature	20.20-21.20 °C	
Test type	Static	
Photoperiod/light intensity	16:8-h light:dark	
Dilution water	Moderately hard reconstituted water	
pH	7.93-8.02	
Hardness	90 mg/L as CaCO3	
Alkalinity	63 mg/L as CaCO3	
Conductivity	275-296 uS/cm	
Dissolved Oxygen	8.8-9.2 mg/L	
Feeding	None	

Reference	Overmyer *et al.* 2003	*S. vittatum*
Parameter	**Value**	**Comment**
Purity of test substance	≥ 98 %	
Concentrations measured?	Yes	
Measured is what % of nominal?	About 25%	
Chemical method documented?	Yes, GC-MS	
Concentration of carrier (if any) in test solutions	0.7mL acetone/ 150mL ~ 4.5 mL/L	
Concentration 1 Nom/Meas (μg/L)	1000/ 247	5 reps with 15 per
Concentration 2 Nom/Meas (μg/L)	500/ 109	5 reps with 15 per
Concentration 3 Nom/Meas (μg/L)	250/ 61	5 reps with 15 per
Concentration 4 Nom/Meas (μg/L)	125/ 22	5 reps with 15 per
Concentration 5 Nom/Meas (μg/L)	61/ 12	5 reps with 15 per
Concentration 6 Nom/Meas (μg/L)	31/ 7.9	5 reps with 15 per
Control	Solvent control and water only	5 reps with 15 per
LC50; indicate calculation method	54.20 (44.70-66.43) μg/L	Probit method

Other notes:

Nom LC50 also given: 283.00 (237.69-340.79) ug/L.

About concentrations: "Because concentrations of the insecticides detected in the water of the flasks after 48 h were much lower than the initial concentrations, the geometric mean of the initial and final concentrations for each of the six treatment levels was calculated for use in determination of the LC50 value for each insecticide. So the geomean is shown as measured above"

MIXTURES:
Mixtures of carbaryl, and malathion; and chlorpyrifos and malathion; and all three pesticides showed greater than additive toxicity. These results are expressed in toxic units (TU), the concentrations of the individual constituents are not clear, so no synergistic ratios can be calculated.

Reliability points taken off for:
Documentation: Hypothesis tests (8)
Acceptability: Measured conc w/in 20% of nominal (4), Carrier solvent (4), Appropriate size (3), Organisms randomized (1), Exposure type (2), Random design (2), Hypothesis tests (3)

Toxicity Data Summary
Streptocephalus sudanicus

Study: Lahr J, Badji A, Marquenie S, Schuiling E, Ndour KB, Diallo AO, Everts JW. 2001. Acute Toxicity of Locust Insecticides to Two Indigenous Invertebrates from Sahelian Temporary Ponds. Ecotoxicol. Environ. Saf. 48:66-75.

Relevance	Reliability
Score: 100	Score: 75.5
Rating: R	Rating: R

Reference	**Lahr *et al.* 2001**	***S. sudanicus***
Parameter	**Value**	**Comment**
Test method cited	ASTM	
Phylum	Arthropoda	
Class	Crustacea/Brachiopoda	
Order	Anostraca	
Family	Stretocephalidae	
Genus	*Streptocephalus*	
Species	*sudanicus*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Adult females	
Source of organisms	Nearby ponds	
Have organisms been exposed to contaminants?	Maybe	
Animals acclimated and disease-free?	Not properly, only 2 h	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	No	
Effect 1	Mortality/immobility/disorientation*	
Control response 1	< 10%	
Temperature	ca. 27 °C	Monitored During test
Test type	Static	
Photoperiod/light intensity	Ambient 13:11 light:dark	
Dilution water	Reconstituted water	
pH	5.9 ± 0.4	
Hardness	Ca & Mg: 0.3 & 7 mg/L as CaCO3	
Alkalinity	NR	
Conductivity	100 uS/cm	
Dissolved Oxygen	56%	Monitored during test

Reference	Lahr *et al.* 2001	*S. sudanicus*
Parameter	**Value**	**Comment**
Feeding	None	
Purity of test substance	Formulation with high percent AI-1230 g/L AI**	>99%
Concentrations measured?	NR	
Measured is what % of nominal?	NR	
Chemical method documented?	NR	
Concentration of carrier (if any) in test solutions	Acetone max 0.5 mL/L	
Concentration 1 Nom (μg/L)	5-10 concentrations, logarithmically spaced	1 reps with 10 per (but tests repeated 3x, w varying concentrations)
Control	solvent	2 reps with 10 per
EC50, 48 h	67,750 (52,220-90,300) μg/L ***	parametric method of Kooijman (1981)

Other notes:

* states animals suffering form immobility and almost all those suffering disorientation eventually died, so all counted as acute endpoints

** density of malathion is 1.23 g/mL so this is apparently nearly 100% malathion

***EC_{50} geomean of 3 tests

Reliability points taken off for:
Documentation: Analytical method (4), Nominal concentrations (3), Measured concentrations (3), Alkalinity (2), Hypothesis tests (8)
Acceptability: Measured conc w/in 20% of nominal (4), Appropriate size (3), Prior contamination (4), Organisms randomized (1), Proper acclimation (1), Alkalinity (2), Dissolved oxygen (6), Temperature > +/- 1°C (3), Random design (2), Hypothesis tests (3)

Toxicity Data Summary

Utterbackia imbecillis

Study: Keller AE, Ruessler DS. 1997. The toxicity of malathion to unionid mussels: Relationship to expected environmental concentrations. *Environmental Toxicology and Chemistry* **16**:1028-1033.

Relevance
Score: 92.5 (no control response)
Rating: R

Reliability
Score: 81
Rating: R

Reference	**Keller & Ruessler 1997**	***U. imbecillis***
Parameter	**Value**	**Comment**
Test method cited	EPA 540/9-85-001 EPA 440/5-86-001	
Phylum	Mollusca	
Class	Bivalvia	
Order	Unionoida	
Family	Unionidae	
Genus	*Utterbackia*	
Species	*imbecillis*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Mature glochidia Juvenile adults (5–8 cm)	(0.2–0.4 mm diam) Transf 7-19 days
Source of organisms	Collected from adult females	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48hr and 96hr	
Data for multiple times?	Yes	
Effect 1	Mortality	Ability to close when NaCl added
Control response 1	NR	
Temperature	25°C 32°C	
Test type	Static	
Photoperiod/light intensity	12 : 12	
Dilution water	DI water + $MgCl_2$ + NaCl + KCl + H_2CO_3 or dilution of well water	EPA 440/5-86-001
pH	Soft 7.5 (0.12)	

Reference	Keller & Ruessler 1997	*U. imbecillis*
Parameter	**Value**	**Comment**
	Mod hard 7.9 (0.23)	
Hardness	Soft 47 (5) Mod hard 76 (19)	
Alkalinity	Soft 40 (11) Mod hard 64 (12)	
Conductivity	Soft 131 (22) Mod hard 258 (56)	
Dissolved Oxygen	NR	
Feeding	none	
Purity of test substance	96%	
Concentrations measured?	Yes but NR	
Measured is what % of nominal?	Recovery 100-126%	
Chemical method documented?	Yes. GC	J. Chromatogr. Sci. 13:291–295 1975
Concentration of carrier (if any) in test solutions	Acetone	
Concentration 1 Nom/Meas (μg/L)	5 conc NR	3-4 x (50-100 gloc) 2-4 x (10-20 juv) 2-4 x (5-10 adults)
Control	Water and solvent	Same as above
LC_{50}; Probit analysis 95% CI (nom conc, mg/L)	Gloc 24hr – 366 48hr – 324 24hr – 366 Juv 24hr - 667 48hr – 363 72hr - 262 96hr – 219 Juv 24hr - 341 48hr – 196 72hr - 161 96hr – 74 Juv 24hr - 568 48hr – 365 72hr - 295 96hr – 215 Juv 24hr - 391 48hr – 280 72hr - 165 96hr – 40	(pH 7.5, 25C) (pH 7.5, 32C) (pH 7.9, 25C) (pH 7.9, 32C) (pH 7.5, 25C) (pH 7.5, 32C)

Other notes:
Some LC_{50} are above water solubility (140 mg/L)

Fifty percent mortality was not observed for adults of V. lienosa, U. imbecillis, or E. icterina at concentrations of up to 350 mg/L after 96 h of exposure.

Reliability points taken off for:
Documentation: Nominal concentrations (3), Measured concentrations (3), Dissolved oxygen (4), Minimum significant difference (2), % control at NOEC/LOEC (2)
Acceptability: Measured conc w/in 20% of nominal (4), Exceed 2x water solubility (4), Carrier solvent (4), Organisms randomized (1), Dissolved oxygen (6), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Various mussels

Glochidia: *Megalonaias nervosa, Lampsilis teres, or Lampsilis siliquoidea*
Juveniles: *Lampsilis straminea claibornensis, Lampsilis subangulata, and Elliptio icterina*
Adults: *Elliptio icterina*

Study: Keller AE, Ruessler DS. 1997. The toxicity of malathion to unionid mussels: Relationship to expected environmental concentrations. *Environmental Toxicology and Chemistry* **16**:1028-1033.

<u>Relevance</u>
Score: 92.5 (no control response)
Rating: R

<u>Reliability</u>
Score: 81
Rating: R

Reference	**Keller & Ruessler 1997**	**Various mussels**
Parameter	**Value**	**Comment**
Test method cited	EPA 540/9-85-001 EPA 440/5-86-001	
Phylum	Mollusca	
Class	Bivalvia	
Order	Unionoida	
Family	Unionidae	
Genus	*Megalonaias, Lampsilis, Elliptio*	
Species	Listed above	
Family in North America?	Yes	
Age/size at start of test/growth phase	Mature glochidia Juvenile Adults E. icterina (7–9.5 cm)	(0.2–0.4 mm diam) Transf 7-19 days
Source of organisms	Collected from adult females	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48hr and 96hr	
Data for multiple times?	yes	
Effect 1	Mortality	Ability to close when NaCl added
Control response 1	NR	
Temperature	25°C 32°C	

Reference	**Keller & Ruessler 1997**	**Various mussels**
Parameter	**Value**	**Comment**
Test type	Static	
Photoperiod/light intensity	12 : 12	
Dilution water	DI water + $MgCl_2$ + NaCl + KCl + H_2CO_3 or dilution of well water	EPA 440/5-86-001
pH	Soft 7.5 (0.12) Mod hard 7.9 (0.23)	
Hardness	Soft 47 (5) Mod hard 76 (19)	
Alkalinity	Soft 40 (11) Mod hard 64 (12)	
Conductivity	Soft 131 (22) Mod hard 258 (56)	
Dissolved Oxygen	NR	
Feeding	none	
Purity of test substance	96%	
Concentrations measured?	Yes but NR	
Measured is what % of nominal?	Recovery 100-126%	
Chemical method documented?	Yes. GC	J. Chromatogr. Sci. 13:291–295 1975
Concentration of carrier (if any) in test solutions	Acetone, NR	
Concentration 1 Nom/Meas (µg/L)	5 conc, NR	3-4 x (50-100 gloc) 2-4 x (10-20 juv) 2-4 x (5-10 adults)
Control	Water and solvent	Same as above
LC50; Probit analysis 95% CI (nom conc, mg/L)	**Glochidea** L siliquoidea, 24hr – 8 48hr - 7 L teres 4hr - 28 L siliquoidea, 24hr – 8 48hr - 7 M nervosa 24hr - 22 **Juveniles** E icterina 24hr – 61 48hr – 54 72hr - 50 96hr – 32 L subangulata 24hr – 43 48hr – 32 72hr - 32 96hr – 28	 (pH 7.9, 25C) (pH 7.5, 25C) (pH 7.5, 25C)

Other notes: Fifty percent mortality was not observed for adults of V. lienosa, U. imbecillis, or E. icterina at concentrations of up to 350 mg/L after 96 h of exposure
Reliability points taken off for:
<u>Documentation:</u> Nominal concentrations (3), Measured concentrations (3), Dissolved oxygen (4), Minimum significant difference (2), % control at NOEC/LOEC (2)
<u>Acceptability:</u> Measured conc w/in 20% of nominal (4), Exceed 2x water solubility (4), Carrier solvent (4), Organisms randomized (1), Dissolved oxygen (6), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Villosa lienosa

Study: Keller AE, Ruessler DS. 1997. The toxicity of malathion to unionid mussels: Relationship to expected environmental concentrations. *Environmental Toxicology and Chemistry* **16**:1028-1033.

Relevance
Score: 92.5 (no control response)
Rating: R

Reliability
Score: 81
Rating: R

Reference	**Keller and Ruessler 1997**	***V. lienosa***
Parameter	**Value**	**Comment**
Test method cited	EPA 540/9-85-001 EPA 440/5-86-001	
Phylum	Mollusca	
Class	Bivalvia	
Order	Unionoida	
Family	Unionidae	
Genus	*Villosa*	
Species	*lienosa*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Mature glochidia Juvenile Adults (2.5–5.0 cm)	(0.2–0.4 mm diam) Transf 7-19 days
Source of organisms	Collected from adult females	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48hr and 96hr	
Data for multiple times?	NR	
Effect 1	Mortality	Ability to close when NaCl added Activity and heartbeat reaction to stimulation
Control response 1	NR	
Temperature	25C 32C	
Test type	Static	
Photoperiod/light intensity	12 : 12	
Dilution water	DI water + $MgCl_2$ + NaCl + KCl + H_2CO_3 or dilution of well water	EPA 440/5-86-001
pH	Soft 7.5 (0.12)	

Reference	Keller and Ruessler 1997	*V. lienosa*
Parameter	**Value**	**Comment**
	Mod hard 7.9 (0.23)	
Hardness	Soft 47 (5) Mod hard 76 (19)	
Alkalinity	Soft 40 (11) Mod hard 64 (12)	
Conductivity	Soft 131 (22) Mod hard 258 (56)	
Dissolved Oxygen	NR	
Feeding	none	
Purity of test substance	96%	
Concentrations measured?	Yes but NR	
Measured is what % of nominal?	Recovery 100-126%	
Chemical method documented?	Yes. GC	J. Chromatogr. Sci. 13:291–295 1975
Concentration of carrier (if any) in test solutions	Acetone, NR	
Concentration 1 Nom/Meas (μg/L)	5 conc NR	3-4 x (50-100 gloc) 2-4 x (10-20 juv) 2-4 x (5-10 adults)
Control	Water and solvent	3-4 x (50-100 gloc) 2-4 x (10-20 juv) 2-4 x (5-10 adults)
LC50; Probit analysis 95% CI (nom conc, mg/L)	Gloc 24hr – 54 Juv 24hr >231 48hr – 181 72hr - 154 96hr – 109 Juv 24hr - 463 48hr – 192 72hr - 140 96hr – 111 Juv 24hr - 263 48hr – 160 72hr - 96 96hr – 74	(pH 7.9, 25C) (pH 7.9, 32C) (pH 7.5, 25C) (pH 7.5, 32C)

Other notes:
Fifty percent mortality was not observed for adults of V. lienosa, U. imbecillis, or E. icterina at concentrations of up to 350 mg/L after 96 h of exposure

Reliability points taken off for:
<u>Documentation:</u> Nominal concentrations (3), Measured concentrations (3), Dissolved oxygen (4), Minimum significant difference (2), % control at NOEC/LOEC (2)

Acceptability: Measured conc w/in 20% of nominal (4), Exceed 2x water solubility (4), Carrier solvent (4), Organisms randomized (1), Dissolved oxygen (6), Random design (2), Dilution factor (2), Hypothesis tests (3)

Toxicity Data Summary

Villosa villosa

Study: Keller AE, Ruessler DS. 1997. The toxicity of malathion to unionid mussels: Relationship to expected environmental concentrations. *Environmental Toxicology and Chemistry* **16**:1028-1033.

Relevance	Reliability
Score: 92.5 (no control response)	Score: 81
Rating: R	Rating: R

Reference	**Keller and Ruessler 1997**	***V. villosa***
Parameter	**Value**	**Comment**
Test method cited	EPA 540/9-85-001 EPA 440/5-86-001	
Phylum	Mollusca	
Class	Bivalvia	
Order	Unionoida	
Family	Unionidae	
Genus	*Villosa*	
Species	*villosa*	
Family in North America?	Yes	
Age/size at start of test/growth phase	Mature glochidia Juvenile	(0.2–0.4 mm diam) Transf 7-19 days
Source of organisms	Collected from adult females	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	NR	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48hr and 96hr	
Data for multiple times?	yes	
Effect 1	Mortality	Ability to close when NaCl added
Control response 1	NR	
Temperature	25°C 32°C	
Test type	Static	
Photoperiod/light intensity	12 : 12	
Dilution water	DI water + $MgCl_2$ + NaCl + KCl + H_2CO_3 or dilution of well water	EPA 440/5-86-001
pH	Soft 7.5 (0.12) Mod hard 7.9 (0.23)	

Reference	Keller and Ruessler 1997	*V. villosa*
Parameter	**Value**	**Comment**
Hardness	Soft 47 (5) Mod hard 76 (19)	
Alkalinity	Soft 40 (11) Mod hard 64 (12)	
Conductivity	Soft 131 (22) Mod hard 258 (56)	
Dissolved Oxygen	NR	
Feeding	none	
Purity of test substance	96%	
Concentrations measured?	Yes but NR	
Measured is what % of nominal?	Recovery 100-126%	
Chemical method documented?	Yes. GC	J. Chromatogr. Sci. 13:291–295 1975
Concentration of carrier (if any) in test solutions	Acetone	
Concentration 1 Nom/Meas (μg/L)	5 conc, NR	3-4 x (50-100 gloc) 2-4 x (10-20 juv) 2-4 x (5-10 adults)
Control	Water and solvent	Same as above
LC_{50}; Probit analysis 95% CI (nom conc, mg/L)	Gloc 24hr – 117 48hr - 119 Juv 24hr - 431 48hr – 354 72hr - 255 96hr – 142 Juv 24hr - 326 48hr – 220 72hr - 199 96hr – 180	(pH 7.9, 32C) (pH 7.9, 25C) (pH 7.5, 32C)

Other notes:
Fifty percent mortality was not observed for V. lienosa, U. imbecillis, or E. icterina at concentrations of up to 350 mg/L after 96 h of exposure

Reliability points taken off for:
Documentation: Nominal concentrations (3), Measured concentrations (3), Dissolved oxygen (4), Minimum significant difference (2), % control at NOEC/LOEC (2)
Acceptability: Measured conc w/in 20% of nominal (4), Exceed 2x water solubility (4), Carrier solvent (4), Organisms randomized (1), Dissolved oxygen (6), Random design (2), Dilution factor (2), Hypothesis tests (3)